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DECLARATION

I, Koichi OISHI Patent Attorney, of OISHI & PARTNERS, 4th Floor, Kanda-ON Building, 1-10, Kandasudacho, Chiyoda-ku, Tokyo 101-0041 Japan, hereby certify that I am the translator of the certified official copy of the documents in respect of an application for a Patent filed in Japan on November 22, 2002 under Patent Application No. 2002-339857 and that the following is a true and correct translation to the best of my knowledge and belief.

Koichi OISHI
Patent Attorney

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[TITLE OF THE INVENTION]

AN OPTICAL RECORDING MEDIUM

[CLAIMS]

[Claim 1] An optical recording medium comprising a substrate for constituting one surface of the optical recording medium, a protective layer constituting the other surface of the optical recording medium and a plurality of information recording layers provided between the substrate and the protective layer, a predetermined information recording layer(s) other than a farthest information recording layer from the surface of the optical recording medium serving as a light incidence plane among the one surface and the other surface of the optical recording medium comprising a recording film including a plurality of inorganic reaction films, a first dielectric film located on the side of the light incidence plane with respect to the recording film and a second dielectric film located on the side of the substrate with respect to the recording film, the first dielectric film containing a material prepared by adding nitrogen (N_2) to an oxide and the second dielectric film having a lower thermal conductivity than that of the first dielectric film.

[Claim 2] An optical recording medium in accordance with Claim 1, wherein the first dielectric film contains at least one of Ta_2O_5 and TiO_2.

[Claim 3] An optical recording medium in accordance with Claim 1 or 2, wherein the recording layer is constituted so that data can be recorded therein by projecting a laser beam having a wavelength of 380 nm to 450 nm thereonto.

[Claim 4] An optical recording medium in accordance with any one of Claims 1 to 3, wherein the second dielectric film contains a mixture of ZnS and SiO_2.

[Claim 5] An optical recording medium in accordance with any one of Claims 1 to 4, wherein the plurality of inorganic reaction films include a first inorganic reaction film containing copper (Cu) as a primary component and a second inorganic reaction film containing silicon (Si) as a primary component.

[Claim 6] An optical recording medium in accordance with Claim 5, wherein the first reaction film is added with at least one element selected from a group consisting of aluminum (Al), zinc (Zn), magnesium (Mg) and gold (Au).

[Claim 7] An optical recording medium comprising a substrate for constituting one surface of the optical recording medium, a protective layer constituting the other surface of the optical recording medium and a plurality of information recording layers provided between the substrate and the protective layer, a predetermined information recording layer(s) other than a farthest information recording layer from the surface of the optical recording medium serving as a light incidence plane among the one surface and the other surface of the optical recording medium comprising a recording film including a plurality of inorganic reaction films, a first dielectric film located on the side of the light incidence plane with respect to the recording film and a second dielectric film located on the side of the substrate with respect to the

recording film, the first dielectric film containing a material prepared by adding nitrogen (N_2) to an oxide and the second dielectric film containing a mixture of ZnS and SiO_2.

[Claim 8] An optical recording medium in accordance with Claim 7, wherein the first dielectric film contains at least one of Ta_2O_5 and TiO_2.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[FIELD OF THE INVENTION]

The present invention relates to an optical recording medium and, in particular, to an optical recording medium which includes a plurality of laminated information recording layers and in which data can be recorded by a user.

[0002]

[DESCRIPTION OF THE PRIOR ART]

Optical recording media such as the CD, DVD and the like have been widely used as recording media for recording digital data. Such optical recording media require improvement in ability to record large amounts of data and various proposals have been made in order to increase the data recording capacity thereof. One of these is an optical recording medium having two information recording layers and such an optical recording medium has been already put to the practical use as an optical recording medium adapted to enable only data reading, such as the DVD-Video and the DVD-ROM. An optical recording medium adapted only for reading data and provided with two information recording layers is formed by laminating two substrates each having pits constituting an information recording layer on the surface thereof via an intermediate

layer.

[0003]

Further, an optical recording medium having a plurality of information recording layers has been recently proposed in connection with optical recording media in which data can be recorded by the user and a patent publication No. 1 discloses a data rewritable type optical recording medium having a plurality of information recording layers. In the optical recording medium disclosed in the patent publication No. 1, each recording layer includes a recording film formed of a phase change material and dielectric films (protective films) sandwiching the recording film therebetween and two information recording layers each having such a configuration are laminated via an intermediate layer.

[0004]

In the case where data are to be recorded in an optical recording medium having a plurality of recording films in which data can be recorded by the user, a laser beam whose power is modulated so as to be equal to a recording power *Pw* sufficiently higher than a reproducing power *Pr* is focused onto one of the information recording layers and projected thereonto, thereby changing the state of a recording film included in the information recording layer and forming a recording mark at a predetermined region of the recording film. Since the optical characteristics differ between the region of the recording film where a recording mark is formed and blank regions of the recording film, data can be reproduced by projecting a laser beam whose power is set to a reproducing power *Pr* onto the recording film and detecting an amount of the laser beam reflected by the recording film.

[0005]

In an optical recording medium including a plurality of

information recording layers, namely, an L0 layer, an L1 layer, an L2 layer, an L3 layer, an L4 layer, ..., where the L0 layer is the farthest information recording layer from the light incident plane and the L1 layer, the L2 layer, the L3 layer, the L4 layer, ... are a second farthest information recording layer from the light incident plane, a third farthest information recording layer from the light incident plane, a fourth farthest information recording layer from the light incident plan, a fifth farthest information recording layer from the light incident plane, ..., recording data in and reproduction of data from the L0 layer is accomplished by projecting a laser beam onto the L0 layer via the L1 layer, the L2 layer, the L3 layer, the L4 layer, ... Similarly, when data are to be recorded in and reproduced from the L1 layer, a laser beam is projected onto the L1 layer via the L2 layer, the L3 layer, the L4 layer, ... and when data are to be recorded in and reproduced from the L2 layer, a laser beam is projected onto the L2 layer via the L3 layer, the L4 layer, ... Therefore, in order to record data in or reproduce data from the lower information recording layers (located farther from the light incidence plane) in a desired manner, it is necessary for the upper information recording layers (located closer to the light incidence plane) to have a sufficiently high light transmittance and it is accordingly usual for each of the upper information recording layers to have no reflective film or to have only an extremely thin reflective film.

[0006]

[PATENT PUBLICATION NO. 1]

Japanese Patent Application Laid Open No. 2001-243655

[PROBLEMS TO BE SOLVED BY THE INVENTION]

In the optical recording medium having a plurality of laminated information recording layers, since each of the L1 layer, the L2 layer, the

L3 layer, the L4 layer, ... has no reflective film or has only an extremely thin reflective film, a sufficient enhancement effect cannot be obtained. As a result, it is difficult to obtain sufficiently high output (modulation) of a signal in each of the L1 layer, the L2 layer, the L3 layer, the L4 layer, ... In order to solve such a problem, it might be considered effective to employ a material having a high refractive index n for forming a dielectric film included in each of the L1 layer, the L2 layer, the L3 layer, the L4 layer, ... However, if a material having a high refractive index n is employed for forming a dielectric film included in each of the L1 layer, the L2 layer, the L3 layer, the L4 layer, ..., the extinction coefficient k of the dielectric film increases.

[0007]

In addition, since no or only a very low heat radiation effect can be obtained in the L1 layer, the L2 layer, the L3 layer, the L4 layer, ... or the Lm layer, heat generated by a laser beam is not readily radiated, thereby degrading the signal characteristic. In order to solve such a problem, it might be considered effective to employ a material having a high thermal conductivity for forming a dielectric film included in each of the L1 layer, the L2 layer, the L3 layer, the L4 layer, ... However, when a material having a high thermal conductivity is employed for forming a dielectric film included in each of the L1 layer, the L2 layer, the L3 layer, the L4 layer, ..., it is difficult to simultaneously obtain a high heat radiation characteristic and a high optical characteristic.

[0008]

It is therefore an object of the present invention to provide an optical recording medium which includes a plurality of information recording layers and in which the heat radiation characteristic and the optical property of at least a predetermined information recording

layer(s) other than the information recording layer (L0 layer) farthest from a light incidence plane are improved.

[0009]

[MEANS FOR SOLVING THE PROBLEMS]

An optical recording medium according to the present invention is characterized by comprising a substrate for constituting one surface of the optical recording medium, a protective layer constituting the other surface of the optical recording medium and a plurality of information recording layers provided between the substrate and the protective layer and in that a predetermined information recording layer(s) other than a farthest information recording layer from the surface of the optical recording medium serving as a light incidence plane among the one surface and the other surface of the optical recording medium comprises a recording film including a plurality of inorganic reaction films, a first dielectric film located on the side of the light incidence plane with respect to the recording film and a second dielectric film located on the side of the substrate with respect to the recording film, and that the first dielectric film contains a material prepared by adding nitrogen (N_2) to an oxide and the second dielectric film has a lower thermal conductivity than that of the first dielectric film.

[0010]

According to the present invention, since the first dielectric film contains a material prepared by adding nitrogen (N_2) to an oxide, it is possible to increase heat radiation characteristics of the information recording layer including the first dielectric film and at the same time, the first dielectric film can exhibit a high refractive index n and a low extinction coefficient k with respect to a laser beam of desired wavelength used for recording data and reproducing data. More

specifically, since the refractive index n and the extinction coefficient k of some oxides greatly depend on the wavelength of the incident light, the refractive index n of the first dielectric film becomes low or the extinction coefficient k of the dielectric layer becomes high depending upon the wavelength of the laser beam used for recording and reproducing data. However, in the case where nitrogen (N_2) is added to the oxide like the present invention, since the dependency of the refractive index n and the extinction coefficient k on the wavelength of a laser beam is varied in accordance with the amount of nitrogen (N_2) to be added, the first dielectric film can exhibit a high refractive index n and a low extinction coefficient k with respect to a laser beam of desired wavelength used for recording data and reproducing data. As described above, in the case where the material used for forming the dielectric layer has a high refractive index n, it is possible to increase modulation and it becomes easy to control the reflection coefficient of the first dielectric film and on the other hand, in the case where the material used for forming the first dielectric film has a low extinction coefficient k, it is possible to increase the recording sensitivity of the optical recording medium. Further, since the thermal conductivity of the second dielectric film is lower than that of the first dielectric film, it is possible to prevent heat radiation characteristics of the information recording layer from excessively increasing, thereby lowering the recording sensitivity of the optical recording medium. Thus, according to the present invention, it is possible to simultaneously improve heat radiation characteristics and optical characteristics.

[0011]

Further, it is preferable for the first dielectric film to contain at least one of Ta_2O_5 and TiO_2. In the case where nitrogen (N_2) is added to

Ta_2O_5 or TiO_2, reduction in the extinction coefficient k is pronounced and the refractive index n of the dielectric layer is markedly increased with respect to a laser beam in the blue wavelength band. Therefore, it is possible to further increase modulation and the recording sensitivity of an optical recording medium.

[0012]

Furthermore, it is preferable to record data in a recording film by projecting a laser beam having a wavelength of 380 nm to 450 nm thereonto. In the case where a predetermined amount of nitrogen (N_2) is added to each of the above mentioned oxides, it exhibits a higher refractive index n and a lower extinction coefficient k with respect to light having a wavelength of 380 nm to 450 nm than the higher refractive index n and extinction coefficient k in the case where no nitrogen (N_2) is added thereto.

[0013]

Moreover, it is preferable for the second dielectric film to contain a mixture of ZnS and SiO_2. The mixture of ZnS and SiO_2 can form a film at a high film forming rate with high productivity and has a relatively high refractive index n and a relatively low extinction coefficient k with respect to a laser beam having a wavelength of blue light. Further, since the mixture of ZnS and SiO_2 has a lower thermal conductivity than Ta_2O_5 or TiO_2, it is possible to prevent the recording sensitivity of the information recording layer other than the farthest information recording layer from the light incidence plane from being lowered even in the case where the first dielectric film is formed of Ta_2O_5 or TiO_2.

[0014]

Furthermore, it is preferable for the plurality of inorganic reaction films to include a first inorganic reaction film containing copper (Cu) as a

primary component and a second inorganic reaction film containing silicon (Si) as a primary component. In the case where the plurality of inorganic reaction includes a first inorganic reaction film containing copper (Cu) as a primary component and a second inorganic reaction film containing silicon (Si) as a primary component, it is possible to decrease the difference in light transmittances with respect to a laser beam having a wavelength of blue light between a case where the first inorganic reaction film and the second inorganic reaction film are laminated and a case where the first inorganic reaction film and the second inorganic reaction film are mixed to 4 % or lower and it is possible to suppress a load applied to the global environment. Moreover, it is preferable for the first inorganic reaction film to be added with at least one element selected from a group consisting of aluminum (Al), zinc (Zn), tin (Sb), magnesium (Mg) and gold (Au). In the case where the first inorganic reaction film is added with at least one element selected from a group consisting of aluminum (Al), zinc (Zn), tin (Sb), magnesium (Mg) and gold (Au), it is possible to lower a noise level of a reproduced signal and improve a long term storage reliability of an optical recording medium.

[0015]

In another aspect, an optical recording medium according to the present invention is characterized by comprising a substrate for constituting one surface of the optical recording medium, a protective layer constituting the other surface of the optical recording medium and a plurality of information recording layers provided between the substrate and the protective layer and in that a predetermined information recording layer(s) other than a farthest information recording layer from the surface of the optical recording medium serving

as a light incidence plane among the one surface and the other surface of the optical recording medium comprises a recording film including a plurality of inorganic reaction films, a first dielectric film located on the side of the light incidence plane with respect to the recording film and a second dielectric film located on the side of the substrate with respect to the recording film and that the first dielectric film contains a material prepared by adding nitrogen (N_2) to an oxide and the second dielectric film contains a mixture of ZnS and SiO_2.

[0016]

According to the present invention, since the first dielectric film contains a material prepared by adding nitrogen (N_2) to an oxide and the second dielectric film contains a mixture of ZnS and SiO_2, it is possible to increase heat radiation characteristics of the information recording layer including the first dielectric film and the second dielectric film and at the same time, the first dielectric film can exhibit a high refractive index n and a low extinction coefficient k with respect to a laser beam of desired wavelength used for recording data and reproducing data. Further, it is possible to increase the recording sensitivity and productivity of an optical recording medium.

[0017]

Further, it is preferable for the first dielectric film to contain at least one of Ta_2O_5 and TiO_2. In the case where nitrogen (N_2) is added to Ta_2O_5 or TiO_2, reduction in the extinction coefficient k is pronounced and the refractive index n of the dielectric layer is markedly increased with respect to a laser beam in the blue wavelength band. Therefore, it is possible to further increase heat radiation characteristics and the recording sensitivity of an optical recording medium.

[0018]

[DESCRIPTION OF THE PREFERRED EMBODIMENTS]

Hereinafter, a preferred embodiment of the present invention will now be explained with reference to the accompanying drawings.

[0019]

Figure 1 (a) is a schematic partially cutaway perspective view showing an external appearance of an optical recording disc which is a preferred embodiment of the present invention and Figure 1 (b) is a schematic enlarged cross-sectional view showing a section indicated by the symbol A in Figure 1 (a).

[0020]

An optical recording medium 10 shown in Figure 1 (a) and Figure 1 (b) has a disc-like shape having an outer diameter of about 120 mm and a thickness of about 1.2 mm and as shown in Figure 1 (b), the optical recording medium 10 includes a support substrate 11, a transparent intermediate layer 12, a light transmission layer (protective layer) 13, an L0 layer 20 formed between the support substrate 11 and the transparent intermediate layer 12, and an L1 layer 30 formed between the transparent layer 12 and the light transmission layer 13. The L0 layer 20 constitutes an information recording layer far from a light incident plane 13a and is constituted by laminating a reflective film 21, a fourth dielectric film 22, an L0 recording film 23 and a third dielectric film 24 from the side of the support substrate 11. On the other hand, the L1 layer 30 constitutes an information recording layer close to the light incident plane 13a and is constituted by laminating a second dielectric film 31, an L1 recording film 32 and a first dielectric film 33 from the side of the support substrate 11. Here, the fourth dielectric film 22, the third dielectric film 24, the second dielectric layer and the first dielectric layer mean the fourth closest dielectric film to the light incident plane

13a, the third closest dielectric film to the light incident plane 13a, the second closest dielectric film to the light incident plane 13a and the closest dielectric film to the light incident plane 13a, respectively.

[0021]

As described later, when data are to be recorded in and reproduced from the L0 layer 20 or when data are to be recorded in and reproduced from the L1 layer 30, a laser beam L having a blue wavelength band, namely, a wavelength of 380 nm to 450 nm is projected onto the optical recording medium 10 from the side of the light transmission layer 13 and is focused onto the L0 layer 20 or the L1 layer 30.

[0022]

Unlike the L0 layer 20, the L1 layer 30 includes no reflective film. This is because a laser beam L is projected onto the L0 layer 20 via the L1 layer 30 when data are to be recorded in and reproduced from the L0 layer 20 and therefore, it is necessary for the L1 layer 30 to have a high light transmittance in order to record data in and reproduce data from the L0 layer 20 in a desired manner. However, in an optical recording medium to which the present invention can be applied, it is not absolutely necessary for the L1 layer 30 to include no reflective film and the L1 layer 30 may include a thin reflective film unless it disturbs data recording in and data reproduction from the L0 layer 20.

[0023]

The support substrate 11 is a disc-like substrate used for ensuring a thickness (about 1.2 mm) required for the optical recording medium 10. On one of the surfaces of the support substrate 11, grooves 11a and lands 11b are spirally formed from a portion in the vicinity of the center portion of the support substrate 11 toward the outer circumference thereof. The

grooves 11a and/or the lands 11b serve as a guide track for the laser beam L when data are to be recorded in the L0 layer 20 or when data are to be reproduced from the L0 layer 20. The depth of the groove 11a is not particularly limited and is preferably set to 10 nm to 40 nm. The pitch of the grooves 11a is not particularly limited and is preferably set to 0.2 μm to 0.4 μm. The support substrate 11 can be formed of various materials and the support substrate 11 can be formed of glass, ceramic or resin, for example. Among these, resin is preferably used for forming the support substrate 11 since resin can be easily shaped. Illustrative examples of resins suitable for forming the support substrate 11 include polycarbonate resin, polyolefin resin, acrylic resin, epoxy resin, polystyrene resin, polyethylene resin, polypropylene resin, silicone resin, fluoropolymers, acrylonitrile butadiene styrene resin, urethane resin and the like. Among these, polycarbonate resin and polyolefin resin are most preferably used for forming the support substrate 11 from the viewpoint of easy processing and the like. In this embodiment, since a laser beam L is not transmitted through the support substrate 11 when data are recorded or to be reproduced, it is not required for the support substrate 11 to have a high light transmittance.

[0024]

The transparent intermediate layer 12 serves to space the L0 layer 20 and the L1 layer 30 apart by a physically and optically sufficient distance. Grooves 12a and lands 12b are formed on the surface of the transparent intermediate layer 12. The grooves 12a and/or lands 12b formed on the surface of the transparent intermediate layer 12 serve as a guide track for the laser beam L when data are to be recorded in the L1 layer 30 or when data are to be reproduced from the L1 layer 30. The depth of the groove 12a and the pitch of the grooves 12a can be set to be

substantially the same as those of the grooves 11a formed on the surface of the support substrate 11. It is preferable to form the transparent intermediate layer 12 so as to have a thickness of 5 μm to 50 μm and it is more preferable to form it so as to have a thickness of 10 μm to 40 μm. The material for forming the transparent intermediate layer 12 is not particularly limited and an ultraviolet ray curable acrylic resin is preferably used for forming the transparent intermediate layer 12. It is necessary for the transparent intermediate layer 12 to have sufficiently high light transmittance since the laser beam L passes through the transparent intermediate layer 12 when data are to be recorded in the L0 layer 20 and data recorded in the L0 layer 20 are to be reproduced.

[0025]

The light transmission layer 13 serves to transmit the laser beam L and the light incident plane 13a is constituted by one of the surfaces thereof. It is preferable to form the light transmission layer 13 so as to have a thickness of 30 μm to 200 μm. The material for forming the light transmission layer 13 is not particularly limited and, similarly to the transparent intermediate layer 12, an ultraviolet ray curable acrylic resin is preferably used for forming the light transmission layer 13. As described above, it is necessary for the light transmission layer 13 to have sufficiently high light transmittance since the laser beam L passes through the transparent intermediate layer 13 when data are to be recorded and data are to be reproduced.

[0026]

Next, the respective films constituting the L0 layer 20 and the L1 layer 30 will be described below.

[0027]

As shown in Figure 2 (a), in this embodiment, each of the L0

recording film 23 included in the L0 layer 20 and the L1 recording film 32 included in the L1 layer 30 is constituted by laminating an inorganic reaction film 51 and an inorganic reaction film 52 so that the inorganic reaction film 51 is located on the side of the support substrate 11 and the inorganic reaction film 52 is located on the side of the light transmission layer 13. As shown in Figure (a), the inorganic reaction film 51 and the inorganic reaction film 52 are stacked in a region of the L0 recording film 23 or the L1 recording film 32 where no data are recorded and when a laser beam L having a power equal to or higher than a predetermined power is projected onto the L0 recording film 23 or the L1 recording film 32, as shown in Figure 2 (b), an element contained in the inorganic reaction film 51 and an element contained in the inorganic reaction film 52 are partially or totally mixed with each other by heat generated by the irradiation with the laser beam L, thereby forming a recording mark M. Since the reflection coefficients with respect to a laser beam L for reproducing data are greatly different between a mixed region of the L0 recording film 23 or the L1 recording film 32 where a recording mark M is formed and other regions of the L0 recording film 23 or the L1 recording film 32, data can be recorded in and reproduced from the L0 recording film 23 or the L1 recording film 32 utilizing the difference in the reflection coefficients with respect to a laser beam L for reproducing data.

[0028]

Therefore, in order to obtain a reproduced signal having a high output, it is necessary to select materials for forming the inorganic reaction film 51 and the inorganic reaction film 52 so that the reflection coefficients with respect to a laser beam L for reproducing data are greatly different between a case where the inorganic reaction film 51 and

the inorganic reaction film 52 are stacked as shown in Figure 2 (a) and a case where an element contained in the inorganic reaction film 51 and an element contained in the inorganic reaction film 52 are mixed with each other as shown in Figure 2 (b). However, if the difference in light transmittances between a case where the inorganic reaction film 51 and the inorganic reaction film 52 of the L1 recording film 32 are stacked and a case where an element contained in the inorganic reaction film 51 and an element contained in the inorganic reaction film 52 of the L1 recording film 32 are mixed with each other is great, when the laser beam L is focused onto the L0 layer 20, the amount of the laser beam L projected onto the L0 layer 20 and the amount of the laser beam L reflected from the L0 layer 20 greatly changes depending upon whether the region of the L1 layer 30 through which the laser beam L passes is a region where a recording mark M is formed or a region where no recording mark M is formed. As a result, the recording characteristics of the L0 layer 20 and the amplitude of a signal reproduced from the L0 layer 20 change greatly depending upon whether the region of the L1 layer 30 through which the laser beam L passes is a region where a recording mark M is formed or a region where no recording mark M is formed, whereby it is impossible to record data in and reproduce data from the L0 layer 20 in a desired manner.

[0029]

In particular, when data recorded in the L0 layer 20 are reproduced, if the region of the L1 layer 30 through which the laser beam L passes contains a boundary between a region where a recording mark M is formed and a region where no recording mark M is formed, since the distribution of the reflection coefficient is not uniform at the spot of the laser beam L and it is difficult to stably detect the amount of the laser

beam L reflected from the L0 layer 20, the above problem becomes particularly serious.

[0030]

Therefore, it is necessary to select materials for forming the inorganic reaction film 51 and the inorganic reaction film 52 of the L1 recording film 32 so that the reflection coefficients with respect to a laser beam L for reproducing data between a case where the inorganic reaction film 51 and the inorganic reaction film 52 are stacked and a case where a case where an element contained in the inorganic reaction film 51 and an element contained in the inorganic reaction film 52 are mixed with each other is great and the difference in light transmittances between the case where the inorganic reaction film 51 and the inorganic reaction film 52 are stacked and a case where the case where an element contained in the inorganic reaction film 51 and an element contained in the inorganic reaction film 52 are mixed with each other is small. Concretely, in order to record data in and reproduce data from the L0 layer 20 in a desired manner, it is preferable for the difference in light transmittances between the case where the inorganic reaction film 51 and the inorganic reaction film 52 are stacked and a case where the case where an element contained in the inorganic reaction film 51 and an element contained in the inorganic reaction film 52 are mixed with each other to be equal to or smaller than 4 % and it is more preferable for it to be equal to or smaller than 2 %.

[0031]

Thus, in this embodiment, the inorganic reaction film 51 of the L1 recording film 32 is formed of a material containing one of copper (Cu) and silicon (Si) as a primary component and the inorganic reaction film 52 of the L1 recording film 32 is formed of a material containing the

other of copper (Cu) and silicon (Si) as a primary component, whereby the difference in light transmittances with respect to a laser beam L having a wavelength of 380 nm to 450 nm between the case where the inorganic reaction film 51 and the inorganic reaction film 52 are stacked and a case where the case where an element contained in the inorganic reaction film 51 and an element contained in the inorganic reaction film 52 are mixed with each other can be set to be equal to or smaller than 4 % and it is possible to record data in and reproduce data from the L0 layer 20 in a desired manner. In the case where the inorganic reaction film 51 of the L1 recording film 32 is formed of a material containing one of copper (Cu) and silicon (Si) as a primary component and the inorganic reaction film 52 of the L1 recording film 32 is formed of a material containing the other of copper (Cu) and silicon (Si) as a primary component, it is possible to set the difference in light transmittances with respect to a laser beam L having a wavelength of 405 nm used for recording data in and reproducing data from a next generation type optical recording medium between the case where the inorganic reaction film 51 and the inorganic reaction film 52 are stacked and a case where the case where an element contained in the inorganic reaction film 51 and an element contained in the inorganic reaction film 52 are mixed with each other can to be equal to or smaller than 1 %. Further, since copper (Cu) and silicon (Si) are contained in the inorganic reaction film 51 and the inorganic reaction film 52 as a primary component, it is possible to suppress a load applied to the global environment. In particular, it is preferable for the inorganic reaction film 51 to contain copper (Cu) as a primary component and for the inorganic reaction film 52 to contain silicon (Si) as a primary component.

[0032]

It is preferable for the inorganic reaction film containing copper (Cu) as a primary component among the inorganic reaction film 51 and the inorganic reaction film 52 to be added with aluminum (Al), zinc (Zn), tin (Sb), magnesium (Mg) or gold (Au). In the case where the inorganic reaction film containing copper (Cu) as a primary component is added with aluminum (Al), zinc (Zn), tin (Sb), magnesium (Mg) or gold (Au), it is possible to lower a noise level of a reproduced signal and improve a long term storage reliability of an optical recording medium. In this specification, the statement that an element is contained in the inorganic reaction film as a primary component means that the content (atomic %) of the element in the inorganic reaction film is highest.

[0033]

Here, it is unnecessary to select materials for forming the inorganic reaction film 51 and the inorganic reaction film 52 of the L0 recording film 23 so that the difference in light transmittances between a case where the inorganic reaction film 51 and the inorganic reaction film 52 of the L0 recording film 23 are stacked and a case where an element contained in the inorganic reaction film 51 and an element contained in the inorganic reaction film 52 of the L0 recording film 23 are mixed with each other becomes small but the inorganic reaction film 51 and the inorganic reaction film 52 of the L0 recording film 23 may be formed of the same materials used for forming the inorganic reaction film 51 and the inorganic reaction film 52 of the L1 recording film 32.

[0034]

Since the laser beam L passes through the L1 recording film 32 when data are to be recorded in the L0 layer 20 and data recorded in the L0 layer 20 are to be reproduced, it is necessary for the L1 recording film 32 to have a high light transmittance and it is therefore preferable to

form the L1 recording film 32 so as to be thinner than the L0 recording film 23.

[0035]

Concretely, it is preferable to form the L0 recording film 23 so as to have a thickness of 2 nm to 40 nm and form the L1 recording film 32 so as to have a thickness of 2 nm to 15 nm. In the case where the thickness of the L0 recording film 23 and the thickness of the L1 recording film 32 are both thinner than 2 nm, the change in optical property between before and after recording data is small and on the other hand, in the case where the thickness of the L1 recording film 32 exceeds 15 nm, the light transmittance of the L1 layer 30 is lowered and the recording characteristic and the reproducing characteristic of the L0 information recording layer 20 are degraded. Further, in the case where the thickness of the L0 recording film 23 exceeds 40 nm, the recording sensitivity of the L0 layer 20 is degraded. Furthermore, it is preferable for a ratio of the thickness of the inorganic reaction film 51 to the thickness of the inorganic reaction film 52 (the thickness of the inorganic reaction film 51 / the thickness of the inorganic reaction film 52) to be 0.2 to 5.0.

[0036]

The third dielectric film 24 and the fourth dielectric film 22 formed so as to sandwich the L0 recording film 23 therebetween serve as protective layers for protecting the L0 recording film 23 and the first dielectric film 34 and the second dielectric film 32 formed so as to sandwich the L1 recording film 32 therebetween serve as protective layers for protecting the L1 recording film 32. Therefore, degradation of data recorded in the L0 layer 20 and L1 layer 30 can be prevented over a long period.

[0037]

The fourth dielectric film 22, the third dielectric film 24, the second dielectric film 32 and the first dielectric film 34 also serve to increase the difference in optical properties between before and after recording data and it is therefore preferable to form the fourth dielectric film 22, the third dielectric film 24, the second dielectric film 32 and the first dielectric film 34 of a material having a high refractive index *n*. On the other hand, when a laser beam L is projected, the recording sensitivity of the optical recording medium 10 is lowered if a large amount of the laser beam L is absorbed in the fourth dielectric film 22, the third dielectric film 24, the second dielectric film 32 and the first dielectric film 34. It is therefore preferable to form the fourth dielectric film 22, the third dielectric film 24, the second dielectric film 32 and the first dielectric film 34 of a material having a low extinction coefficient *k*. Further, in this embodiment, since the L1 layer 30 includes no reflective film and the heat radiation characteristic of the L1 layer 30 is lower than that of the L0 layer 20, it is preferable to select the material for forming the second dielectric film 32 and the first dielectric film 34 with consideration to the heat radiation characteristic of the L1 layer 30.

[0038]

Therefore, in this embodiment, each of the fourth dielectric film 22, the third dielectric film 24 and the second dielectric film 31 is formed of the mixture of ZnS and SiO_2 (mole ratio: 80:20) and on the other hand, the first dielectric film 34 is formed of a material containing an oxide as a primary component and nitrogen (N_2) as an additive.

[0039]

Since the mixture of ZnS and SiO_2 (mole ratio: 80:20) can form a film at a high film forming rate with high productivity and has a

relatively high refractive index n and a relatively low extinction coefficient k with respect to a blue laser beam having a wavelength λ of 380 nm to 450 nm, each of the fourth dielectric film 22 and the third dielectric film 24 is formed of the mixture of ZnS and SiO_2 (mole ratio: 80:20). Although the mixture of ZnS and SiO_2 has a relatively low thermal conductivity, since the L0 layer 20 includes the reflective film 21 and has a high heat radiation characteristic, even in the case where each of the fourth dielectric film 22 and the third dielectric film 24 is formed of the mixture of ZnS and SiO_2, the recording characteristics of the L0 layer 20 cannot be lowered.

[0040]

Further, as described later in detail, since the material containing an oxide as a primary component and nitrogen (N_2) as an additive has a high refractive index n and a low extinction coefficient k with respect to a laser beam having a blue wavelength band, namely, a wavelength of 380 nm to 450 nm and the thermal conductivity of the material containing an oxide as a primary component and nitrogen (N_2) as an additive is higher than the mixture of ZnS and SiO_2 (mole ratio: 80:20), in the case where the first dielectric film 34 is formed of a material containing an oxide as a primary component and nitrogen (N_2) as an additive, the heat radiation characteristic of the L1 layer 30 can be improved. To the contrary, in the case where the second dielectric film 31 is formed of the material containing an oxide as a primary component and nitrogen (N_2) as an additive, the heat radiation characteristic of the L1 layer 30 becomes too high and the recording sensitivity of the L1 layer 30 is sometimes lowered. Therefore, in this embodiment, similarly to the fourth dielectric film 22 and the third dielectric film 24, the second dielectric film 31 is formed of the mixture of ZnS and SiO_2 (mole ratio: 80:20).

[0041]

Here, since the material containing an oxide as a primary component and nitrogen (N_2) as an additive has more excellent optical characteristics, namely, a higher refractive index n and a lower extinction coefficient k, with respect to a laser beam having a blue wavelength band, namely, a wavelength of 380 nm to 450 nm than those of the mixture of ZnS and SiO_2 (mole ratio: 80:20), it is more advantageous to use the material containing an oxide as a primary component and nitrogen (N_2) as an additive for forming the first dielectric film 33 on the side of the light incidence plane 13a than for forming the second dielectric film 31.

[0042]

It is preferable to select an oxide of tantalum (Ta) or titanium (Ti), namely, Ta_2O_5 or TiO_2 as an oxide contained in the first dielectric film 33 as a primary component. In the case where Ta_2O_5 or TiO_2 is employed as an oxide contained in the first dielectric film 33 as a primary component, it is possible to effectively protect the L1 recording film 32 while preventing a load applied to the global environment from being increased.

[0043]

Further, since the oxide contained in the first dielectric film 33 as a primary component is added with nitrogen (N_2), the first dielectric film 33 can exhibit a high refractive index n and a low extinction coefficient k with respect to a laser beam having a desired wavelength. More specifically, since the refractive index n and the extinction coefficient k of the above mentioned oxide greatly depend on the wavelength of the incident light, in the case where the dielectric film is formed of the above mentioned oxide, the refractive index n of the

dielectric film becomes low or the extinction coefficient k of the dielectric film becomes high depending upon the wavelength of the laser beam used for recording and reproducing data. However, since it is possible to vary the dependency of the refractive index n and the extinction coefficient k on the wavelength of the laser beam by adding nitrogen (N_2) to a dielectric film containing the above mentioned oxide as a primary component, it is possible to form a dielectric film having a sufficiently high refractive index n and a sufficiently low extinction coefficient k with respect to a laser beam of desired wavelength by controlling the amount of nitrogen added to the dielectric film.

[0044]

Concretely, assuming that a refractive index and an extinction coefficient of the dielectric layer in the case where no nitrogen (N_2) is added to the above mentioned oxide are "$n0$" and "$k0$", respectively and that a refractive index and an extinction coefficient of the dielectric layer in the case where nitrogen (N_2) is added to the above mentioned oxide are "$n1$" and "$k1$", respectively, the value ($n0 - n1$) tends to become small (become large in the minus direction) large as the wavelength of a laser beam becomes shorter and the value ($k0 - k1$) tends to become large as the wavelength of a laser beam becomes shorter and these tendencies are varied depending upon the added amount of nitrogen (N_2). Further, with respect to a laser beam L having the blue wavelength band, namely, a wavelength λ of 380 nm to 450 nm used for recording data in and reproducing data from a next-generation type optical recording medium, the value ($n0 - n1$) can be made negative and/or the value ($k0 - k1$) can be made positive by adding a predetermined amount of nitrogen (N_2) to the above mentioned oxide. In other words, it is possible to obtain a higher refractive index n and a lower extinction coefficient k than those

in the case where no nitrogen (N_2) is added to the above mentioned oxide.

[0045]

In particular, the refractive index *no* of Ta_2O_5 in the case where no nitrogen (N_2) is added thereto is greatly lowered as the wavelength of a laser beam becomes shorter, while the refractive index *n1* of Ta_2O_5 in the case where a predetermined amount of nitrogen (N_2) is added thereto greatly increases as the wavelength of a laser beam becomes shorter. Further, the extinction coefficient *k* of Ta_2O_5 is lower as a whole in the case where a predetermined amount of nitrogen (N_2) is added thereto than in the case where no nitrogen (N_2) is added thereto, namely, $k0 > k1$ and this tendency becomes prominent as the wavelength of a laser beam becomes shorter. Furthermore, the refractive index *no* of TiO_2 in the case where no nitrogen (N_2) is added thereto is hardly changed depending upon the wavelength of a laser beam, while the refractive index *n1* of TiO_2 in the case where a predetermined amount of nitrogen (N_2) is added thereto increases as the wavelength of a laser beam becomes shorter. Moreover, the extinction coefficient *k* of TiO_2 is lower as a whole in the case where a predetermined amount of nitrogen (N_2) is added thereto than in the case where no nitrogen (N_2) is added thereto, namely, $k0 > k1$ and this tendency becomes prominent as the wavelength of a laser beam becomes shorter.

[0046]

Thus, in the case where at least one of Ta_2O_5 and TiO_2 is employed as a primary component of the first dielectric film 33 and a predetermined amount of nitrogen (N_2) is added to the at least one of Ta_2O_5 and TiO_2, it is possible to markedly improve the optical characteristics, namely, the refractive index *n* and the extinction coefficient *k* of the first dielectric film 33 with respect to a laser beam L

having the blue wavelength band, namely, a wavelength λ of 380 nm to 450 nm in comparison with the case where no nitrogen (N_2) is added to the at least one of Ta_2O_5 and TiO_2.

[0047]

A preferred amount of nitrogen (N_2) to be added to an oxide depends upon the kind of the oxide to be contained in the first dielectric film 33 as a primary component and a wavelength of a laser beam L used for recording or reproducing data. In the case where data are recorded and reproduced using a laser beam L having the blue wavelength band, namely, a wavelength λ of 380 nm to 450 nm, when the oxide to be contained in the first dielectric film 33 as a primary component is Ta_2O_5, it is preferable for an added amount of nitrogen (N_2) to be 1 to 12 atomic % and it is more preferable for an added amount of nitrogen (N_2) to be 2 to 10 atomic %. On the other hand, when the oxide to be contained in the first dielectric film 33 as a primary component is TiO_2, it is preferable for an added amount of nitrogen (N_2) to be 1 to 5 atomic % and it is more preferable for an added amount of nitrogen (N_2) to be 2 to 4 atomic %. Here, the amount of nitrogen (N_2) added to the first dielectric film 33 can be measured based on areas of respective peaks detected using an ESCA (X-ray photoelectron spectroscopy: XPS).

[0048]

As described above, in this embodiment, since the first dielectric film 33 located on the side of the light incidence plane 13a is formed of the material containing an oxide as a primary component and nitrogen (N_2) as an additive and the second dielectric film 31 located on the side of the support substrate 11 is formed of the mixture of ZnS and SiO_2 (mole ratio: 80:20) whose thermal conductivity is lower than that of the material containing an oxide as a primary component and nitrogen (N_2)

as an additive, it is possible to simultaneously improve the heat radiation characteristic and the optical characteristic of the L1 layer 30 including no reflective film or an extremely thin reflective film and the recording sensitivity of the optical recording medium 10 can be increased.

[0049]

The thickness of each of the fourth dielectric film 22, the third dielectric film 24, the second dielectric film 31 and the first dielectric film 33 is not particularly limited and it preferably has a thickness of 1 nm to 150 nm. In the case where the thickness of each of the fourth dielectric film 22, the third dielectric film 24, the second dielectric film 31 and the first dielectric film 33 is thinner than 1 nm, each of the fourth dielectric film 22, the third dielectric film 24, the second dielectric film 31 and the first dielectric film 33 does not sufficiently serve as a protective layer. On the other hand, in the case where the thickness of each of the fourth dielectric film 22, the third dielectric film 24, the second dielectric film 31 and the first dielectric film 33 exceeds 150 nm, a long time is required for forming it, thereby lowering the productivity of the optical recording medium 10 and there is some risk of cracking the L0 recording film 23 and the L1 recording film 32 due to internal stress.

[0050]

Here, each of the fourth dielectric film 22, the third dielectric film 24, the second dielectric film 31 and the first dielectric film 33 may have a single-layered structure or may have a multi-layered structure including a plurality of dielectric films. In the case of forming the first dielectric film 33 so as to have a multi-layered structure including a plurality of dielectric films, it is preferable for all of the dielectric films to be formed of the material containing an oxide as a primary component and nitrogen (N_2) as an additive but it is also possible for only some of

the dielectric films constituting the first dielectric film 33 to be formed of the material containing an oxide as a primary component and nitrogen (N_2) as an additive.

[0051]

The reflective film 21 serves to reflect the laser beam L entering through the light incidence plane 13a so as to emit it from the light transmission layer 13 and radiate heat generated in the L0 recording film 23. The thickness of the reflective film 21 is preferably formed so as to have a thickness of 20 nm to 200nm. In the case where the reflective film 21 is thinner than 20 nm, it is difficult to radiate heat generated in the L0 recording film 23 in a desired manner and, on the other hand, in the case where the thickness of the reflective film 21 exceeds 200 nm, a long time is required for forming it, thereby lowering the productivity of the optical recording medium 10 and there is some risk of cracking the reflective film 21 due to internal stress. The material used to form the reflective film 21 is not particularly limited and the reflective film 21 can be formed of magnesium (Mg), aluminum (Al), titanium (Ti), chromium (Cr), iron (Fe), cobalt (Co), nickel (Ni), copper (Cu), zinc (Zn), germanium (Ge), silver (Ag), platinum (Pt), gold (Au) and the like. Among these materials, it is preferable to form the reflective film 21 of a metal material having a high reflection characteristic, such as aluminum (Al), gold (Au), silver (Ag), copper (Cu) or alloy containing at least one of these metals.

[0052]

When data recorded in the optical recording medium 10 having the above described structure are to reproduced, a laser beam L is projected onto the light incidence plane 13a and an amount of the laser beam L reflected from the optical recording medium 10 is detected. More

specifically, since the reflection coefficient of a region of the L0 recording film 23 or the L1 recording film 32 where the element contained in the inorganic reaction film 51 and the element contained in the inorganic film 52 are mixed with each other and a recording mark M is formed differs from that of a region of the L0 recording film 23 or the L1 recording film 32 where the element contained in the inorganic reaction film 51 and the element contained in the inorganic film 52 are not mixed with each other and no recording mark M is formed, if a laser beam L is focused onto one of the L0 recording film 23 and the L1 recording film 32 via the light incidence plane 13a and an amount of the laser beam L reflected from the one of the L0 recording film 23 and the L1 recording film 32 is detected, it is possible to judge whether a region of the one of the L0 recording film 23 and the L1 recording film 32 irradiated with the laser beam L is a region where the element contained in the inorganic reaction film 51 and the element contained in the inorganic film 52 are mixed with each other and a recording mark M is formed or a region where the element contained in the inorganic reaction film 51 and the element contained in the inorganic film 52 are not mixed with each other and no recording mark M is formed.

[0053]

In this embodiment, since the first dielectric film 33 located on the side of the light incidence plane 13a is formed of the material containing an oxide as a primary component and nitrogen (N_2) as an additive and the second dielectric film 31 located on the side of the support substrate 11 is formed of the mixture of ZnS and SiO_2 (mole ratio: 80:20) whose thermal conductivity is lower than that of the material containing an oxide as a primary component and nitrogen (N_2) as an additive, it is possible to simultaneously improve the heat radiation characteristic and

the optical characteristic of the L1 layer 30 including no reflective film or an extremely thin reflective film.

[0054]

When data are to be reproduced from the L0 layer 20 disposed far from the light incidence plane 13a, a laser beam L is projected onto the L0 layer 20 via the L1 layer 30 disposed close to the light incidence plane 13a. In this embodiment, since the difference in light transmittances between a region of the L1 layer 30 where a recording mark M is formed and a blank region of the L1 layer 30 where no recording mark M is formed is small, the amplitude of a signal reproduced from the L0 layer 20 does not change greatly depending upon whether the region of the L1 layer 30 through which the laser beam L passes is a region where a recording mark M is formed or a blank region. Further, even in the case where the region of the L1 layer 30 through which the laser beam L projected for reproducing data from the L0 layer 20 passes contains a boundary between a region where a recording mark M is formed and a blank region, it is possible to effectively prevent the distribution of the reflection coefficient at the spot of the laser beam L from greatly varying. Therefore, it is possible to reproduce data recorded in the L0 layer 20 in a desired manner. Similarly, it is possible to record data in the L0 layer 20 in a desired manner.

[0055]

Next, a method for fabricating the optical recording medium 10 according to this preferred embodiment will be described below.

[0056]

Figures 3 to 6 show steps for manufacturing the optical recording medium 10.

[0057]

As shown in Figure 3, the support substrate 11 having the groove 11a and the land 11b on the surface thereof is first fabricated by injection molding using a stamper 40. Then, as shown in Figure 4, the reflective film 21, the fourth dielectric film 22, the L0 recording film 23 (the inorganic reaction film 51 and the inorganic reaction film 52) and the third dielectric film 24 are sequentially formed using a gas phase growth process on substantially the whole surface of the support substrate 11 formed with the groove 11a and the land 11b. Thus, the L0 layer 20 has been completed. At this time, an element contained in the inorganic reaction film 51 of the L0 recording film 23 and an element contained in the inorganic reaction film 52 of the L0 recording film 23 are not mixed with each other.

[0058]

Further, as shown in Figure 5, an ultraviolet ray curable resin is coated on the L0 layer 20 by a spin coating method to form a coating film and the surface of the coating film is irradiated with an ultraviolet ray via a stamper 41 while it is covered by the stamper 41, thereby forming the transparent intermediate layer 12 formed with grooves 12a and lands 12b on the surface thereof.

[0059]

Then, as shown in Figure 6, the second dielectric film 32, the L1 recording film 32 (the inorganic reaction film 51 and the inorganic reaction film 52) and the first dielectric film 33 are sequentially formed using a gas phase growth process on substantially the whole surface of the transparent intermediate layer 12 formed with grooves 12a and lands 12b. The first dielectric film 33 can be formed by a gas phase growth process using an oxide to be contained in the first dielectric film 33 as a primary component in an nitrogen (N_2) gas atmosphere. For example,

when the first dielectric film 33 is to be formed by a sputtering process, a mixed gas of argon (Ar) gas and nitrogen (N_2) gas is used as sputtering gas and an oxide to be contained in the first dielectric film 33 as a primary component is used for a target. The amount of nitrogen (N_2) to be added to an oxide to be contained in the first dielectric film 33 as a primary component can be controlled by controlling the amount of nitrogen (N_2) gas in the sputtering gas. Thus, the L1 layer 30 has been completed. At this time, an element contained in the inorganic reaction film 51 of the L1 recording film 32 and an element contained in the inorganic reaction film 52 of the L1 recording film 32 are not mixed with each other.

[0060]

Finally, as shown in Figure 1, an ultraviolet ray curable resin is coated on the L1 layer 30 by a spin coating method to form a coating film and the coating film is irradiated with an ultraviolet ray, thereby forming the light transmission layer 13. This completes the fabrication of the optical recording medium 10.

[0061]

As described above, desired digital data can be recorded in the thus fabricated optical recording medium 10 by focusing a laser beam L onto the L0 recording film 23 or the L1 recording film 32 to form a recording mark. Further, after recording data in the L0 recording film 23 or the L1 recording film 32 of the optical recording medium 10, as described above, the digital data recorded in the L0 recording film 23 or the L1 recording film 32 of the optical recording medium 10 can be reproduced by focusing a laser beam L onto the L0 recording film 23 or the L1 recording film 32 and detecting an amount of the laser beam L reflected from the L0 recording film 23 or the L1 recording film 32.

[0062]

As described above, in the optical recording medium 10 according to this embodiment, since the first dielectric film 33 included in the L1 layer 30 is formed of the material containing an oxide as a primary component and nitrogen (N_2) as an additive, it is possible to improve modulation of a reproduced signal and the recording sensitivity of the optical recording medium. In particular, when at least one of Ta_2O_5 and TiO_2 is employed as an oxide to be contained in the first dielectric film 33 as a primary component, it is possible to markedly improve the optical characteristics, namely, the refractive index n and the extinction coefficient k of the first dielectric film 33 with respect to a laser beam L having the blue wavelength band, namely, a wavelength λ of 380 nm to 450 nm.

[0063]

Further, in the optical recording medium 10 according to this embodiment, since the L0 recording film 23 is constituted by laminating the inorganic reaction film containing copper (Cu) as a primary component and the inorganic reaction film containing silicon (Si) as a primary component, it is possible to suppress the difference in light transmittances between a region of the L0 recording film 23 where a recording mark M is formed and a blank region thereof where no recording mark M is formed low while maintaining the difference in reflective coefficients between a region of the L0 recording film 23 where a recording mark M is formed and a blank region thereof to be great. Therefore, it is possible to record data in and reproduce data from the L0 layer 20 in a desired manner. Further, the inorganic reaction layer containing copper (Cu) as a primary component is added with aluminum (Al), zinc (Zn), tin (Sb), magnesium (Mg) and/or gold (Au), it is possible to

lower a noise level of a reproduced signal and improve a long term storage reliability of an optical recording medium 10.

[0064]

Next, a preferred example of a method for optically recording data in the optical recording medium 10 will be described below.

[0065]

Figure 7 is a diagram showing one example of the waveform of a pulse train pattern for modulating the power of the laser beam L used for recording data in the optical recording medium 10, where Figure 7 (a) shows a pulse train pattern used in the case of recording 2T signals, Figure 7 (b) shows a pulse train pattern used in the case of recording 3T signals, Figure 7 (c) shows a pulse train pattern used in the case of recording 4T signals and Figure 7 (d) shows a pulse train pattern used in the case of recording one among a 5T signal to an 8T signal. The pulse train patterns shown in Figure 7 can be used for recording data in both of the L0 layer 20 and the L1 layer 30.

[0066]

As shown in Figures 7 (a) to 7 (d), the pulse train patterns are adapted for modulating the power of the laser beam L between three levels, a recording power *Pw*, an intermediate power *Pm* and a bottom power *Pb* where $Pw > Pm > Pb$.

[0067]

The recording power *Pw* is set to such a high level that an element contained in the inorganic reaction layer 51 of the L0 recording film 23 or the L1 recording film 32 as a primary component and an element contained in the inorganic reaction layer 52 of the L0 recording film 23 or the L1 recording film 32 as a primary component are heated and mixed with each other when the laser beam L whose power is set to

the recording power *Pw* is projected onto the L0 layer 20 or the L1 layer 30. On the other hand, the intermediate power *Pm* and the bottom power *Pb* are set to such low levels that an element contained in the inorganic reaction layer 51 of the L0 recording film 23 or the L1 recording film 32 as a primary component and an element contained in the inorganic reaction layer 52 of the L0 recording film 23 or the L1 recording film 32 as a primary component cannot be substantially mixed when the laser beam L whose power is set to the intermediate power *Pm* or the bottom power *Pb* is projected onto the L0 layer 20 or the L1 layer 30. In particular, the bottom power *Pb* is set to such an extremely low level that the L0 recording film 23 or the L1 recording film 32 is hardly heated when the laser beam L whose power is set to the bottom power *Pb* is projected onto the L0 layer 20 or the L1 layer 30 and that the L0 recording film 23 or the L1 recording film 32 heated by irradiation with the laser beam L whose power is set to the recording power *Pw* can be cooled by irradiation with the laser beam L whose power is set to the bottom power *Pb*.

[0068]

As shown in Figure 7 (a), in the case of recording a 2T signal in the L0 recording film 23 or the L1 recording film 32 of the optical recording medium 10, the number of a recording pulse having a level equal to the recording power *Pw* is set to be "1" and a cooling interval t_{cl} is inserted after the recording pulse. Here, the number of a recording pulse is defined as the number of times the level is raised to a level corresponding to the recording power *Pw*. Further, in this specification, a first recording pulse among recording pulses in the pulse train pattern is referred to as a top pulse, a last recording pulse is referred to as a last pulse and a recording pulse(s) between the top pulse and the last pulse is

referred to as a multi pulse. However, as shown in Figure 7 (a), in the case where the number of recording pulse is 1, the recording pulse is referred to as a top pulse.

[0069]

In the cooling interval t_{cl}, the power of the laser beam L is set to the bottom power *Pb*. In this manner, in this specification, a last interval during which the power of the laser beam L is set to the bottom power *Pb* is referred to as a cooling period. Further, a period from a time at which the top pulse rises to a time at which the cooling interval starts is referred to as a heating period. In the case of recording a 2T signal in the L0 recording film 23 or the L1 recording film 32, the power of the laser beam L is modulated in such a manner that it is set to the intermediate power *Pm* until a time t11, set to the recording power *Pw* during a time period t_{top} from the time t11 to a time t12, set to the bottom power *Pb* during a time period t_{cl} from a time t12 to a time t13 and set to the intermediate *Pm* after the time t13. Therefore, in the case of recording a 2T signal in the L0 recording film 23 or the L1 recording film 32, a period from the time t11 to the time t12 corresponds to a heating period and a period from the time t12 to the time t13 corresponds to a cooling interval.

[0070]

Further, as shown in Figure 7 (b), in the case of recording a 3T signal in the L0 recording film 23 or the L1 recording film 32, the number of recording pulses is set to be "2" and a cooling interval t_{cl} is inserted after the last recording pulse. Therefore, in the case of recording a 3T signal in the L0 recording film 23 or the L1 recording film 32, the power of the laser beam L is modulated in such a manner that it is set to the intermediate power *Pm* until a time t21, set to the recording power *Pw* during a time period t_{top} from the time t21 to a time t22 and during

time period t_{lp} from a time t23 to a time t24, set to the bottom power *Pb* during a time period t_{off} from a time t22 to a time t23 and during a time period t_{cl} from a time t24 to a time t25, and set to the intermediate *Pm* after the time t25. Thus, in the case of recording a 3T signal in the L0 recording film 23 or the L1 recording film 32, a period from the time t21 to the time t24 corresponds to a heating period and a period from the time t24 to the time t25 corresponds to a cooling interval.

[0071]

Furthermore, as shown in Figure 7 (c), in the case of recording a 4T signal in the L0 recording film 23 or the L1 recording film 32, the number of recording pulses is set to be "3" and a cooling interval t_{cl} is inserted after the last recording pulse. Therefore, in the case of recording a 4T signal in the L0 recording film 23 or the L1 recording film 32, the power of the laser beam L is modulated in such a manner that it is set to the intermediate power *Pm* until a time t31, set to the recording power *Pw* during a time period t_{top} from the time t31 to a time t32, during a time period t_{mp} from a time t33 to a time t34 and during time period t_{lp} from a time t35 to a time t36, set to the bottom power *Pb* during a time period t_{off} from a time t32 to a time t33, during a time period t_{off} from a time t34 to a time t35 and during a time period t_{cl} from a time t36 to a time t37, and set to the intermediate *Pm* after the time t37. Thus, in the case of recording a 4T signal in the L0 recording film 23 or the L1 recording film 32, a period from the time t31 to the time t36 corresponds to a heating period and a period from the time t36 to the time t37 corresponds to a cooling interval.

[0072]

Moreover, as shown in Figure (d), in the case of recording one among a 5T signal to an 8T signal in the L0 recording film 23 or the L1

recording film 32, the number of recording pulses is set to "4", "5", "6" or "7" correspondingly to the formation of a 5T signal, a 6T signal, a 7T signal or an 8T signal and a cooling interval t_{cl} is inserted after the last recording pulse. Therefore, the number of multi pulses is set to "2", "3", "4" or "5" correspondingly to the formation of a 5T signal, a 6T signal, a 7T signal or an 8T signal. In these cases, the power of the laser beam L is modulated in such a manner that it is set to the recording power *Pw* during a time period t_{top} from a time 41 to a time 42, during a time period t_{mp} from a time 43 to a time 44, during a time period t_{mp} from a time 45 to a time 46 and the like and a time period t_{lp} from a time 47 to a time t48, set to the bottom power *Pb* during a time period t_{top} from a time 42 to a time 43, during a time period t_{top} from a time 46 to a time 47 and the like and a time period t_{cl} from a time t48 to a time 49, and set to the intermediate power *Pm* in other time periods. Thus, in the case of recording one among a 5T signal to an 8T signal in the L0 recording film 23 or the L1 recording film 32, a period from the time t41 to the time t48 corresponds to a heating period and a period from the time t48 to the time t49 corresponds to a cooling interval.

[0073]

Thus, the laser beam L whose power is set to the recording power *Pw* is projected onto a region of the L0 recording film 23 or the L1 recording film 32 where a recorded signal, namely, one among a 2T signal to an 8T signal, is to be formed, whereby an element contained in the organic reaction film 51 of the L0 recording film 23 or the L1 recording film 32 as a primary component and an element contained in the organic reaction film 52 of the L0 recording film 23 or the L1 recording film 32 as a primary component are mixed to form a recording mark m having a predetermined length.

[0074]

In this manner, in the pulse train patterns, a recording pulse for forming a recording mark M is divided into $(n-1)$ divided pulses where n is a multiple number of T and an integer from 2 to 8 in the case where 1,7 RLL Modulation Code is used. The power of the laser beam L is set to the recording power Pw or the bottom power Pb alternately during the heating period and the power of the laser beam L is set to the bottom power Pb during the cooling interval t_{cl} after the heating period. Further, the power of the laser beam L is set to the intermediate power Pm during a time period from a time the cooling interval t_{cl} terminates to a time at which a top pulse for forming a next recording mark M rises.

[0075]

The pulse train patterns shown in Figure 7 are particularly suitable for recording data in the L1 layer 30 for the following reason.

[0076]

As described above, since theL1 layer 30 includes no reflective film or merely includes an extremely thin reflective film, heat generated in the L1 layer 30 cannot be released by a reflective film unlike the L0 layer 20. Therefore, it is impossible to sufficiently release heat generated in the L1 layer 30 by the irradiation with a laser beam L whose power is set to the recording power Pw and the signal characteristics of a reproduced signal are sometimes degraded. However, in the case where data are recorded in the L1 layer 30 by a laser beam L whose power is modulated using the pulse train patterns shown in Figure 7, since the power of the laser beam L is modulated to the bottom power Pb immediately after being set to the recording power Pw, it is possible to prevent heat from being accumulated excessively in the L1 layer 30 and a reproduced signal having excellent signal characteristics can be

obtained.

[0077]

The present invention has thus been shown and described with reference to a specific embodiment. However, it should be noted that the present invention is in no way limited to the details of the described arrangements but changes and modifications may be made without departing from the scope of the appended claims.

[0078]

For example, it is not absolutely necessary for the L0 recording film 23 or the L1 recording film 32 to have a two-layers configuration including the inorganic reaction film 51 and the inorganic reaction film 52 and it is possible to form a L0 recording film 23 or a L1 recording film 32 so as to have a three-layers configuration including two inorganic reaction films each containing silicon (Si) as a primary component and an inorganic reaction film disposed between these inorganic reaction films and containing copper (Cu) as a primary component. Further, a film containing a material prepared by mixing an element contained in the inorganic reaction film 51 as a primary component and an element contained in the inorganic reaction film 52 as a primary component may be interposed between the inorganic reaction film 51 and the inorganic reaction film 52. Moreover, in the above described preferred embodiment, although the inorganic reaction film 51 and the inorganic reaction film 52 are formed to be in contact with each other, another thin layer such as a dielectric film may be interposed between the inorganic reaction film 51 and the inorganic reaction film 52 as occasion demands.

[0079]

Furthermore, in the optical recording medium 10 in the above described preferred embodiment, although one of the inorganic reaction

film 51 and the inorganic reaction film 52 contains copper (Cu) as a primary component and the other of the inorganic reaction film 51 and the inorganic reaction film 52 contains silicon (Si) as a primary component, it is not absolutely necessary for one of the inorganic reaction film 51 and the inorganic reaction film 52 to contain copper (Cu) as a primary component and for the other of the inorganic reaction film 51 and the inorganic reaction film 52 to contain silicon (Si) as a primary component and an inorganic reaction film 51 may contain one element selected from the group consisting of aluminum (Al), silicon (Si), germanium (Ge), carbon (C), tin (Sn), gold (Au), zinc (Zn), copper (Cu), boron (B), magnesium (Mg), titanium (Ti), manganese (Mn), iron (Fe), gallium (Ga), zirconium (Zr), silver (Ag), bismuth (Bi) and platinum (Pt) as a primary component and an inorganic reaction film 52 may contain as a primary component an element selected from the above identified group and different from the element contained in the inorganic reaction film 51 as a primary component. However, as described above, in the case where one of the inorganic reaction film 51 and the inorganic reaction film 52 contains copper (Cu) as a primary component and the other of the inorganic reaction film 51 and the inorganic reaction film 52 contains silicon (Si) as a primary component, since it is possible to minimize the difference in light transmittances between a region of the L0 recording film 23 where a recording mark M is formed and a blank region thereof where no recording mark M is formed while maintaining the difference in reflective coefficients between a region of the L0 recording film 23 where a recording mark M is formed and a blank region thereof to be great, it is preferable for one of the inorganic reaction film 51 and the inorganic reaction film 52 included in the L1 recording film 23 to contain copper (Cu) as a primary component and for the other of the inorganic reaction

film 51 and the inorganic reaction film 52 included in the L1 recording film 23 to contain silicon (Si) as a primary component.

[0080]

Further, in the optical recording medium 10 in the above described preferred embodiment, although the second dielectric film 31 is formed of the mixture of ZnS and SiO_2 (mole ratio: 80:20), it is possible to employ other material for forming the second dielectric film 31 insofar as it has a lower thermal conductivity than that of the first dielectric film 33. However, totally considering the film forming characteristics, the optical characteristics, the thermal conductivity of the second dielectric film 31 and the like, it is preferable to form the second dielectric film 31 of the mixture of ZnS and SiO_2 (mole ratio: 80:20). Here, the material for forming the fourth dielectric film 22 and the third dielectric film 24 is not particularly limited and a fourth dielectric film 22 and a third dielectric film 24 may be formed of oxide, nitride, sulfide, carbide of aluminum (Al), silicon (Si), cerium (Ce), titanium (Ti), zinc (Zn), tantalum (Ta) and the like such as SiO_2, Si_3N_4, Al_2O_3, AlN, TaO, ZnS, CeO_2, TiO_2 and the like or a combination thereof.

[0081]

Furthermore, in the optical recording medium 10 in the above described preferred embodiment, although each of the L0 layer 20 and the L1 layer 30 includes the recording film formed of the laminate of the inorganic reaction layer 51 and the inorganic reaction layer 52, an L0 layer 20 which is the farthest information recording layer may be constituted as an information recording layer which has no recording film and is adapted to enable only data reading. In such a case, spiral pit train is formed on the support substrate 11 and data to recorded in an L0 layer 20 are held by the pit train.

[0082]

Moreover, in the above described preferred embodiment, the optical recording medium 10 is constituted as a so-called next generation type optical recording medium constituted so that a laser beam L is projected from the side of the light transmission layer 13 having a very small thickness. However, an optical recording medium to which the present invention can be applied is not limited to such a next generation type optical recording medium and the present invention can be applied to an optical recording medium such as a DVD type optical recording medium constituted so that a laser beam L is projected from the side of a substrate. In a DVD type optical recording medium, a light transmissible substrate having a thickness of about 0.6 mm corresponds to the support substrate 11 of the optical recording medium 10 and a dummy substrate having a thickness of about 0.6 mm corresponds to the light transmission layer 13 of the optical recording medium 10. Thus, a "substrate" of the present invention means a light transmissible substrate in an optical recording medium like a DVD type optical recording medium in which the surface of the substrate constitutes a light incidence plane while a "substrate" of the present invention means a support substrate 11 in the optical recording medium 10 in the above described preferred embodiment in which the surface of the substrate does not constitute a light incidence plane. Similarly, a "protective layer" of the present invention means a light transmission layer in the optical recording medium 10 in the above described preferred embodiment in which the surface of the protective layer constitutes a light incidence plane while a "protective layer" of the present invention means a support substrate in an optical recording medium like a DVD type optical recording medium in which the surface of the protective layer does not constitute a light

incidence plane.

[0083]

Furthermore, an optical recording medium to which the present invention can be applied is not limited to an optical recording medium having two information recording layers but the present invention can be applied to an optical recording medium having three or more information recording layers. In such a case, it is sufficient for a dielectric film included in at least one information recording layer among the information recording layer L1, the information recording layer L2, the information recording layer L3, the information recording layer L4, ... other than the information recording layer L0 farthest from the light incidence plane and located on the side of the light incidence plane to be formed of a material containing an oxide as a primary component and nitrogen (N_2) as an additive and for a dielectric film included in the information recording layer and located on the side of the substrate to be formed of a material whose thermal conductivity is lower than that of the material for forming the dielectric film located on the side of the light incidence plane.

[0084]

Moreover, even in the case where an optical recording medium includes a single information recording layer, if the information recording layer includes a recording film constituted by a plurality of inorganic reaction films and the information recording layer includes no reflective film or merely includes a very thin reflective film since it is required for the information recording layer to have a low reflection coefficient, the present invention can be applied to the optical recording medium by forming a dielectric film located on the side of the light incidence plane of a material containing an oxide as a primary component and nitrogen (N_2)

as an additive and forming a dielectric film on the side of the substrate of a material whose thermal conductivity is lower than that of the material for forming the dielectric film located on the side of the light incidence plane.

[0085]

[WORKING EXAMPLES]

Hereinafter, working examples will be set out in order to further describe the present invention concretely. However, the present invention is in no way limited to the working examples.

[0086]

[Characteristics Comparison Test # 1]

In Characteristics Comparison Test # 1, how the optical characteristics of a dielectric film changed by adding nitrogen (N_2) to Ta_2O_5 contained in the dielectric film as a primary component was measured.

[0087]

A polycarbonate substrate having a thickness of 1.1 mm and a diameter of 120 mm was first set on a sputtering apparatus and a sputtering process was performed at a power of 800 W using a Ta_2O_5 target, thereby forming a dielectric film having a thickness of 30 nm and containing Ta_2O_5 as a primary component on the surface of the polycarbonate substrate. A mixed gas of argon (Ar) gas and nitrogen (N_2) gas was employed as a sputtering gas and samples #1-1 to #1-6 were fabricated to give their dielectric films different nitrogen (N_2) contents from each other by varying the flow rates of argon (Ar) gas and nitrogen (N_2) gas. The relationship between the flow rates of argon (Ar) gas and nitrogen (N_2) gas and the nitrogen (N_2) contents in the dielectric films are shown in Table 1. The amount of nitrogen (N_2) added to each of the

dielectric layer was obtained by multiplying the peak areas of the 4f peak of tantalum (peak position: about 28.2 to 37.4 eV), the 1s peak of oxygen (peak position: about 523 to 543 eV) and the 1s peak of nitrogen (peak position: about 390 to 410 eV) measured by the ESCA (Electron Spectroscopy for Chemical Analysis), namely, XPS (X-ray photoelectron spectroscopy) by the corresponding sensitivity factors of the peaks, namely, 0.596 of that of the 4f peak of tantalum, 2.994 of that of the 1s peak of oxygen and 4.505 of that of the 1s peak of nitrogen.

[0088]

[Table 1]

	Flow rate of Ar gas (sccm)	Flow rate of N_2 gas (sccm)	Amount of Nitrogen (N_2) (atomic%)
Sample #1-1	55	0	0
Sample #1-2	50	5	3.3
Sample #1-3	45	10	6.1
Sample #1-4	40	15	8.4
Sample #1-5	30	25	11.3
Sample #1-6	20	35	12.1

Then, a laser beam having a wavelength of 405 nm and a laser beam having a wavelength of 680 nm were projected onto each of the samples #1-1 to #1-6, whereby the refractive index n and the extinction coefficient k thereof were measured and the relationship between the amount of nitrogen (N_2) added to the dielectric films and the refractive index n of the dielectric film and the relationship between the amount of nitrogen (N_2) added to the dielectric films and the extinction coefficient k of the dielectric film were obtained. The thus obtained relationship between the amount of nitrogen (N_2) added to the dielectric films and the

refractive index n of the dielectric film is shown in Figure 8 and the relationship between the amount of nitrogen (N_2) added to the dielectric films and the extinction coefficient k of the dielectric film is shown in Figure 9.

[0089]

As shown in Figure 8, it was found that the refractive index n of the dielectric film with respect to the laser beam having a wavelength of 405 nm increased as the amount of nitrogen (N_2) added to the dielectric film containing Ta_2O_5 as a primary component was increased, while the refractive index n of the dielectric film with respect to the laser beam having a wavelength of 680 nm decreased as the amount of nitrogen (N_2) added to the dielectric film containing Ta_2O_5 as a primary component was increased. Even when the amount of nitrogen (N_2) added to the dielectric film containing Ta_2O_5 as a primary component was varied, it was found that the refractive index n of the dielectric film with respect to the laser beam having a wavelength of 405 nm increased as the amount of nitrogen (N_2) added to the dielectric film containing Ta_2O_5 as a primary component was increased, while the refractive index n of the dielectric film with respect to the laser beam having a wavelength of 680 nm decreased as the amount of nitrogen (N_2) added to the dielectric film containing Ta_2O_5 as a primary component was increased.

[0090]

On the other hand, as shown in Figure 9, it was found that when nitrogen (N_2) was added to the dielectric film containing Ta_2O_5 as a primary component, both the extinction coefficient k of the dielectric film with respect to the laser beam having a wavelength of 405 nm and the extinction coefficient k of the dielectric film with respect to the laser beam having a wavelength of 680 nm markedly decreased. Even when

the amount of nitrogen (N_2) added to the dielectric film containing Ta_2O_5 as a primary component was varied, it was found that both the extinction coefficient *k* of the dielectric film with respect to the laser beam having a wavelength of 405 nm and the extinction coefficient *k* of the dielectric film with respect to the laser beam having a wavelength of 680 nm markedly decreased. Considering that the extinction coefficient *k* of the dielectric film of the sample # 1-1 added with no nitrogen (N_2) with respect to the laser beam having a wavelength of 405 nm was relatively high, it is reasonable to conclude that the extinction coefficient *k* of the dielectric film can be greatly decreased by adding nitrogen (N_2) to the dielectric film.

[0091]

Then, a laser beam was projected onto the sample # 1-1 whose dielectric film was added with no nitrogen (N_2) and the sample # 1-2 whose dielectric film was added with 3.3 atomic % of nitrogen (N_2) and the refractive index *n* and the extinction coefficient *k* of each dielectric film were measured while varying the wavelength of the laser beam in the range between 350 nm and 800 nm, whereby the relationship between the wavelength of the laser beam and the refractive index *n* of the dielectric films and the relationship between the wavelength of the laser beam and the extinction coefficient *k* of the dielectric films were obtained. The result of measurement of the relationship between the wavelength of the laser beam and the refractive index *n* of the dielectric films is shown in Figure 10 and the result of measurement of the relationship between the wavelength of the laser beam and the extinction coefficient *k* of the dielectric films is shown in Figure 11.

[0092]

As shown in Figure 10, it was found that the refractive index *n* of

the sample # 1-1 including the dielectric film containing Ta_2O_5 as a primary component but no nitrogen (N_2) as an additive decreased as the wavelength of the laser beam became shorter, while the refractive index *n* of the sample # 1-2 including the dielectric film containing Ta_2O_5 as a primary component and 3.3 atomic % of nitrogen (N_2) as an additive increased as the wavelength of the laser beam became shorter and that the refractive index *n* of the sample # 1-2 was higher than that of the sample # 1-1 with respect to the laser beam having a wavelength equal to or shorter than about 470 nm.

[0093]

Further, as shown in Figure 11, it was found that the extinction coefficient *k* of the sample # 1-1 including the dielectric film containing Ta_2O_5 as a primary component but no nitrogen (N_2) as an additive increased as the wavelength of the laser beam became shorter, while the extinction coefficient *k* of the sample # 1-2 including the dielectric film containing Ta_2O_5 as a primary component and 3.3 atomic % of nitrogen (N_2) as an additive was substantially constant even if the wavelength of the laser beam varied and that the extinction coefficient *k* of the sample # 1-1 was higher than that of the sample # 1-2 with respect to the laser beam having a wavelength of from 350 nm to 800 nm.

[0094]

[Characteristics Comparison Test # 2]

In Characteristics Comparison Test # 2, how the optical characteristics of a dielectric film changed by adding nitrogen (N_2) to TiO_2 contained in the dielectric film as a primary component was measured.

[0095]

A polycarbonate substrate having a thickness of 1.1 mm and a

diameter of 120 mm was first set on a sputtering apparatus provided with a target of TiO_2 and a sputtering process was performed at a power of 800 W, thereby forming a dielectric film having a thickness of 30 nm and containing TiO_2 as a primary component on the surface of the polycarbonate substrate. A mixed gas of argon (Ar) gas and nitrogen (N_2) gas was employed as a sputtering gas similarly to Working Example 1 and samples # 2-1 to # 2-8 were fabricated to give their dielectric films different nitrogen (N_2) contents from each other by varying the ratio of argon (Ar) gas and nitrogen (N_2) gas in the mixed gas. The relationship between the ratio of argon (Ar) gas and nitrogen (N_2) gas contained in the mixed gas and the nitrogen (N_2) content in the dielectric film was measured and shown in Table 2. The amount of nitrogen (N_2) added to each of the dielectric film was obtained by multiplying the peak areas of the 2p peak of titanium (peak position: about 443.8 to 473.8 eV), the 1s peak of oxygen (peak position: about 523 to 543 eV) and the 1s peak of nitrogen (peak position: about 390 to 410 eV) measured by the ESCA (Electron Spectroscopy for Chemical Analysis), namely, XPS (X-ray photoelectron spectroscopy) by the corresponding sensitivity factors of the peaks, namely, 0.596 of that of the 4f peak of tantalum, 2.994 of that of the 1s peak of oxygen and 4.505 of that of the 1s peak of nitrogen.

[0096]

[Table 2]

	Flow rate of Ar gas (sccm)	Flow rate of N_2 gas (sccm)	Amount of Nitrogen (N_2) (atomic%)
Sample #2-1	55	0	0
Sample #2-2	52	3	1.7
Sample #2-3	50	5	2.9
Sample #2-4	47	8	3.1
Sample #2-5	45	10	3.3
Sample #2-6	40	15	3.9
Sample #2-7	30	25	5.1
Sample #2-8	20	35	5.7

Then, a laser beam having a wavelength of 405 nm and a laser beam having a wavelength of 680 nm were projected onto each of the samples # 2-1 to # 2-8, whereby the refractive index *n* and the extinction coefficient *k* thereof were measured and the relationship between the amount of nitrogen (N_2) added to the dielectric films containing TiO_2 as a primary component and the refractive index *n* of the dielectric film and the relationship between the amount of nitrogen (N_2) added to the dielectric films and the extinction coefficient *k* of the dielectric film were obtained. The thus obtained relationship between the amount of nitrogen (N_2) added to the dielectric films and the refractive index *n* of the dielectric film is shown in Figure 12 and the relationship between the amount of nitrogen (N_2) added to the dielectric films and the extinction coefficient *k* of the dielectric film is shown in Figure 13.

[0097]

As shown in Figure 12, it was found that when nitrogen (N_2) was added to the dielectric film containing TiO_2 as a primary component, the refractive index *n* of the dielectric film with respect to the laser beam having a wavelength of 405 nm increased but the refractive index *n* of the dielectric film with respect to the laser beam having a wavelength of

680 nm was substantially constant. Even when the amount of nitrogen (N_2) added to the dielectric film containing TiO_2 as a primary component was varied, it was found that the refractive index *n* of the dielectric film with respect to the laser beam having a wavelength of 405 nm increased and the refractive index *n* of the dielectric film with respect to the laser beam having a wavelength of 680 nm was substantially constant.

[0098]

On the other hand, as shown in Figure 13, it was found that when nitrogen (N_2) was added to the dielectric film containing TiO_2 as a primary component, both the extinction coefficient *k* of the dielectric film with respect to the laser beam having a wavelength of 405 nm and the extinction coefficient *k* of the dielectric film with respect to the laser beam having a wavelength of 680 nm markedly decreased but that even if the amount of nitrogen (N_2) added to the dielectric film containing TiO_2 as a primary component was increased, both the extinction coefficient *k* of the dielectric film with respect to the laser beam having a wavelength of 405 nm and the extinction coefficient *k* of the dielectric film with respect to the laser beam having a wavelength of 680 nm hardly decreased but adversely increased.

[0099]

Then, a laser beam was projected onto the sample # 2-1 whose dielectric film was added with no nitrogen (N_2) and the sample # 2-3 whose dielectric film was added with 2.9 atomic % of nitrogen (N_2) and the refractive index *n* and the extinction coefficient *k* of each dielectric film were measured while varying the wavelength of the laser beam in the range between 350 nm and 800 nm, whereby the relationship between the wavelength of the laser beam and the refractive index *n* of the dielectric films and the relationship between the wavelength of the

laser beam and the extinction coefficient k of the dielectric films were obtained. The result of measurement of the relationship between the wavelength of the laser beam and the refractive index n of the dielectric films is shown in Figure 14 and the result of measurement of the relationship between the wavelength of the laser beam and the extinction coefficient k of the dielectric films is shown in Figure 15.

[0100]

As shown in Figure 14, it was found that the refractive index n of the sample # 2-1 including the dielectric film containing TiO_2 as a primary component but no nitrogen (N_2) as an additive did not greatly change even if the wavelength of the laser beam became shorter, while the refractive index n of the sample # 2-3 including the dielectric film containing TiO_2 as a primary component and 2.9 atomic % of nitrogen (N_2) as an additive increased as the wavelength of the laser beam became shorter and the refractive index n thereof was very large with respect to the laser beam in the blue wavelength band.

[0101]

Further, as shown in Figure 15, it was found that both the extinction coefficient k of the sample # 2-1 including the dielectric film containing TiO_2 as a primary component but no nitrogen (N_2) as an additive and the extinction coefficient k of the sample # 2-3 including the dielectric film containing TiO_2 as a primary component and 2.9 atomic % of nitrogen (N_2) as an additive increased as the wavelength of the laser beam became shorter and that the increase in the extinction coefficient k of the sample # 2-1 including the dielectric film containing TiO_2 as a primary component but no nitrogen (N_2) as an additive was more prominent than that of the sample # 2-3 and the extinction coefficient k of the sample # 2-3 was lower than that of the sample # 2-1 irrespective

of the wavelength of the laser beam.

[0102]

[Characteristics Comparison Test # 3]

In Characteristics Comparison Test # 3, various optical recording medium samples were fabricated and recording characteristics of the optical recording medium samples were compared.

[0103]

[Fabrication of Optical Recording Medium Samples]

An optical recording medium sample having the same configuration as that of the optical recording medium shown in Figure 1 was fabricated in the following manner.

[0104]

A disk-like polycarbonate support substrate 11 made of polycarbonate, having a thickness of 1.1 mm and a diameter of 120 mm and formed with grooves 11a and lands 11b on the surface thereof was first fabricated by an injection molding process so that the track pitch (groove pitch) was equal to 0.32 μm.

[0105]

Then, the thus fabricated support substrate 11 was set on a sputtering apparatus and a reflective film 21 consisting of an alloy of silver (Ag), palladium (Pd) and copper (Cu) and having a thickness of 100 nm, a fourth dielectric film 22 containing a mixture of ZnS and SiO_2 (mole ratio thereof was 80:20) and having a thickness of 27 nm, an inorganic reaction film 51 containing Cu as a primary component, added with 23 atomic% of aluminum (Al) and 13 atomic% of gold (Au) and having a thickness of 5 nm, an inorganic reaction film 52 containing Si as a primary component and having a thickness of 5 nm and a third dielectric film 24 containing the mixture of ZnS and SiO_2 (mole ratio

thereof was 80:20) and having a thickness of 25 nm were sequentially formed on the surface of the support substrate 11 on which the grooves 11a and lands 11b were formed, using the sputtering process, thereby forming an L0 layer 20 on the surface of the support substrate 11.

[0106]

Further, the support substrate 11 formed with the L0 layer 20 on the surface thereof was set on a spin coating apparatus and the third dielectric film 24 was coated with an dissolving acrylic ultraviolet curable resin to form a coating layer while the support substrate 11 was being rotated. Then, a stamper formed with grooves and lands was placed on the surface of the coating layer and the surface of the coating layer was irradiated with an ultraviolet ray via the stamper, thereby curing the acrylic ultraviolet curable resin. A transparent intermediate layer 12 having a thickness of 20 μm and formed with grooves 12a and lands 12b on the surface thereof so that the track pitch (groove pitch) was equal to 0.32 μm was formed by removing the stamper.

[0107]

Then, the support substrate 11 formed with the L0 layer 20 and the transparent intermediate layer 12 on the surface thereof was set on the sputtering apparatus and a second dielectric film 31 containing a mixture of ZnS and SiO_2 (mole ratio thereof was 80:20) and having a thickness of 13 nm, an inorganic reaction film 51 containing copper (Cu) as a primary component, added with 23 atomic% of aluminum (Al) and 13 atomic% of gold (Au) and having a thickness of 5 nm, an inorganice reaction film 52 containing silicon (Si) as a primary component and having a thickness of 5 nm and a first dielectric film 33 containing TiO_2 as a primary component and 2.9 atomic % of nitrogen (N_2) as an additive and having a thickness of 27 nm were sequentially formed on the surface

of the transparent intermediate layer 12 formed on the L0 layer 20 using the sputtering process, thereby forming an L1 layer 30 on the surface of the transparent intermediate layer 12. Here, the first dielectric film 33 was formed in the manner of forming the dielectric film of sample # 2-3 in Characteristics Comparison Test # 2.

[0108]

Further, the first dielectric film was coated using the spin coating method with an acrylic ultraviolet curing resin to form a coating layer and the coating layer was irradiated with ultraviolet rays, thereby curing the acrylic ultraviolet curing resin to form a light transmission layer having a thickness of 80 μm.

[0109]

Thus, the optical recording medium sample of Working Example was fabricated.

[0110]

An optical recording medium sample of Comparative Example 1 was fabricated in the manner of the optical recording medium sample of Working Example except that the first dielectric film 33 was formed so as to contain a mixture of ZnS and SiO_2 (mole ratio thereof was 80:20) and have a thickness of 31 nm and the second dielectric film 31 was formed so as to have a thickness of 16 nm.

[0111]

Next, an optical recording medium sample of Comparative Example 2 was fabricated in the manner of the optical recording medium sample of Working Example except that the second dielectric film 31 was formed so as to contain TiO_2 as a primary component and nitrogen (N_2) as an additive and have a thickness of 20 nm.

[0112]

Then, an optical recording medium sample of Comparative Example 3 was fabricated in the manner of the optical recording medium sample of Working Example except that the first dielectric film 33 was formed so as to contain a mixture of ZnS and SiO_2 (mole ratio thereof was 80:20) and have a thickness of 31 nm and the second dielectric film 31 was formed so as to have a thickness of 14 nm.

[0113]

Here, the thicknesses of the first dielectric film 33 and/or the second dielectric film 31 were different between in the optical recording medium samples because they were optimized so as to obtain the highest modulation.

[0114]

[Evaluation # 1 of Optical Recording Medium Samples]

Each of the optical recording medium sample of Working Example, the optical recording medium sample of Comparative Example 1, the optical recording medium sample of Comparative Example 2 and the optical recording medium sample of Comparative Example 3 was set in an optical recording medium evaluation apparatus "DDU1000 "(Product Name) manufactured by Pulstec Industrial Co., Ltd. and a laser beam having a wavelength of 405 nm was focused onto the L1 recording film 32 using an objective lens whose numerical aperture was 0.85 while each optical recording medium sample was rotated at a linear velocity of 5.3 m/sec, thereby recording 2T single signals therein. The power of the laser beam was modulated using the pulse pattern shown in Figure 7 where the intermediate power *Pm* was fixed at 1.5 mW and the bottom power *Pb* was fixed at 0.1 mW, whereas the recording power *Pw* was varied.

[0115]

The 2T singles signals recorded in each of the optical recording

medium sample of Working Example, the optical recording medium sample of Comparative Example 1, the optical recording medium sample of Comparative Example 2 and the optical recording medium sample of Comparative Example 3 by varying the recording power *Pw* of the laser beam were then reproduced and the C/N ratio of each of reproduced signals was measured. The reproducing power *Pr* of the laser beam was set to 0.7 mW. The results of the measurement are shown in Figure 16.

[0116]

As shown in Figure 16, the C/N ratio of the signal obtained by reproducing the 2T single signal recorded in the optical recording medium sample of Working Example was highest.

[0117]

[Evaluation # 2 of Optical Recording Medium Samples]

Further, each of the optical recording medium sample of Working Example, the optical recording medium sample of Comparative Example 1, the optical recording medium sample of Comparative Example 2 and the optical recording medium sample of Comparative Example 3 was set in the above mentioned optical recording medium evaluation apparatus and similarly to in Evaluation # 1 of Optical Recording Medium Samples, random signals including a 2T signal to a 8T signal were recorded in the L1 recording film thereof.

[0118]

The signal recorded in each of the optical recording medium sample of Working Example, the optical recording medium sample of Comparative Example 1, the optical recording medium sample of Comparative Example 2 and the optical recording medium sample of Comparative Example 3 was then reproduced and jitter of a reproduced signal obtained from a track between tracks in which data were recorded

was measured. Here, jitter was clock jitter and the fluctuation σ of the reproduced signal was measured using a time interval analyzer and the clock jitter was calculated as σ/Tw, where Tw was one clock period. The results of the measurement are shown in Figure 17. Further, the recording power *Pw* (the optimum recording power) at which the clock jitter of a reproduced signal was lowest and modulation of the signal obtained by reproducing data recorded at the optimum recording power *Pw* were measured for each optical recording medium sample and the results of the measurement are shown in.

[0119]

[Table 3]

	Optimum Recording Power Pw(mW)	Jitter (%)	Modulation (%)
Working Example	6.4	6.2	51.8
Comparative Example 1	5.8	8.0	42.3
Comparative Example 2	8.6	7.1	44.4
Comparative Example 3	7.0	6.8	47.6

As shown in Figure 17 and Table 3, it was found that the jitter of the signal obtained by reproducing the random signal recorded in the optical recording medium sample of Working Example was 6.2 % and lowest. Further, the recording power *Pw* at which the jitter of a reproduced signal was lowest was 6.4 mW and the recording sensitivity of the optical recording medium sample of Working Example was excellent. Furthermore, it was found that modulation of the signal obtained by reproducing the random signal recorded in the optical recording medium sample of Working Example at the recording power *Pw* at which the jitter of a reproduced signal was lowest was 51.8 % and

highest among modulation of signals obtained by reproducing the random signals recorded in optical recording medium samples at the recording power *Pw* at which the jitter of a reproduced signal was lowest.

[0120]

Here, it was found that the recording power *Pw* at which the jitter of a reproduced signal was lowest was 5.8 mW in the optical recording medium sample of Comparative Example 1 and the recording sensitivity of the optical recording medium sample of Comparative Example 1 was higher than that of the optical recording medium sample of Working Example. On the other hand, the lowest jitter of a reproduced signal obtained from the optical recording medium sample of Comparative Example 1 and was highest among jitter of reproduced signals obtained from the optical recording medium sample of Working Example, the optical recording medium sample of Comparative Example 1, the optical recording medium sample of Comparative Example 2 and the optical recording medium sample of Comparative Example 3. It is reasonable to assume that the lowest jitter of a reproduced signal obtained from the optical recording medium sample of Comparative Example 1 and was highest because modulation of a signal obtained by reproducing random signal recorded at the optimum recording power *Pw* in the optical recording medium sample of Comparative Example 1 was 42.3 % and lowest and each of the second dielectric film 31 and the first dielectric film 33 of the optical recording medium sample of Comparative Example 1 was formed of a mixture of ZnS and SiO_2 (mole ratio thereof was 80:20) so that the heat radiation characteristics thereof were low.

[0121]

Further, it was found that the recording power *Pw* at which the jitter of a reproduced signal was lowest was 8.6 mW in the optical

recording medium sample of Comparative Example 2 and the recording sensitivity of the optical recording medium sample of Comparative Example 2 was lowest among those of the optical recording medium sample of Working Example, the optical recording medium sample of Comparative Example 1, the optical recording medium sample of Comparative Example 2 and the optical recording medium sample of Comparative Example 3. It is reasonable to assume that this is because each of the second dielectric film 31 and the first dielectric film 33 of the optical recording medium sample of Comparative Example 2 was formed of a material containing TiO_2 as a primary component and nitrogen (N_2) as an additive and the heat radiation characteristics thereof were too high.

[0122]

Furthermore, it was found that the recording power *Pw* at which the jitter of a reproduced signal was lowest was 7.0 mW and the lowest jitter was 6.8 % in the optical recording medium sample of Comparative Example 3 and the jitter characteristics of the optical recording medium sample of Comparative Example 3 were relatively good but that the recording sensitivity of the optical recording medium sample of Comparative Example 3 was lower than that of the optical recording medium sample of Working Example and the lowest jitter was higher than that of the optical recording medium sample of Working Example. It is reasonable to assume that this is because the first dielectric film 33 located on the side of the light incidence plane 13a was formed of a mixture of ZnS and SiO_2 (mole ratio thereof was 80:20) so that modulation of a signal obtained by reproducing random signal recorded at the optimum recording power *Pw* in the optical recording medium sample of Comparative Example 3 was 47.6 % and relatively low and the

optical characteristics thereof was poorer than those of the optical recording medium sample of Working Example.

[0123]

[TECHNICAL ADVANTAGE OF THE INVENTION]

As described above, according to the present invention, since among dielectric films included in an information recording layer of an optical recording medium which includes a recording film formed of a plurality of inorganic reaction layers and includes no reflective film or a very thin reflective film and whose radiation characteristics and output (modulation) are low, a dielectric film located on the side of the light incidence plane is formed of a material containing an oxide as a primary component and nitrogen (N_2) as an additive and a dielectric film located on the side of the substrate is formed of a material whose thermal conductivity is lower than that of the material containing an oxide as a primary component and nitrogen (N_2) as an additive, it is possible to improve the recording characteristics of the optical recording medium.

[0124]

Further, in the case where at least one of Ta_2O_5 and TiO_2 is employed as the oxide, the optical characteristics of the dielectric film located on the side of the light incidence plane, namely, a refractive index n and an extinction coefficient k of the dielectric film, with respect to a laser beam L having a blue wavelength band, namely, a wavelength of 380 nm to 450 nm can be markedly improved.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[Figure 1]

Figure 1 (a) is a schematic partially cutaway perspective view showing an external appearance of an optical recording disc which is a preferred embodiment of the present invention and Figure 1 (b) is a

schematic enlarged cross-sectional view showing a section indicated by the symbol A in Figure 1 (a).

[Figure 2]

Figure 2 is an enlarged partial cross sectional view showing an L0 recording film 23 or an L1 recording film 32, where Figure 2 (a) shows the L0 recording film 23 or the L1 recording film 3 in which no data are recorded and Figure 2 (b) shows 2 (a) the L0 recording film 23 or the L1 recording film 3 in which a recording mark M is formed.

[Figure 3]

Figure 3 is a part of steps of a method for fabricating an optical recording medium 10, namely, a step for fabricating a support substrate 11.

[Figure 4]

Figure 4 is a part of steps of a method for fabricating an optical recording medium 10, namely, a step for forming an L0 layer 20.

[Figure 5]

Figure 5 is a part of steps of a method for fabricating an optical recording medium 10, namely, a step for forming a transparent intermediate layer 12.

[Figure 6]

Figure 6 is a part of steps of a method for fabricating an optical recording medium 10, namely, a step for forming an L1 layer 30.

[Figure 7]

Figure 7 is a diagram showing one example of a pulse train pattern for modulating the power of a laser beam L used when data are to be recorded in an optical recording medium 10, wherein Figure 7 (a) shows a pulse train pattern for modulating the power of the laser beam L when a 2T signal is to be recorded in the optical recording medium 10,

Figure 7 (b) shows a pulse train pattern for modulating the power of the laser beam L when a 3T signal is to be recorded in the optical recording medium 10, Figure 7 (c) shows a pulse train pattern for modulating the power of the laser beam L when a 4T signal is to be recorded in the optical recording medium 10 and Figure 7 (d) shows a pulse train pattern for modulating the power of the laser beam L when one among a 5T signal to an 8T signal is to be recorded in the optical recording medium 10.

[Figure 8]

Figure 8 is a graph showing the relationship between the amount of nitrogen (N_2) added to a dielectric film containing Ta_2O_5 as a primary component and the refractive index n of the dielectric film.

[Figure 9]

Figure 9 is a graph showing the relationship between the amount of nitrogen (N_2) added to a dielectric film containing Ta_2O_5 as a primary component and the extinction coefficient k of the dielectric film.

[Figure 10]

Figure 10 is a graph showing the relationship between the wavelength of a laser beam and the refractive index n of a dielectric film containing Ta_2O_5 as a primary component.

[Figure 11]

Figure 8 is a graph showing the relationship between the wavelength of a laser beam and the extinction coefficient k of a dielectric film containing Ta_2O_5 as a primary component.

[Figure 12]

Figure 12 is a graph showing the relationship between the amount of nitrogen (N_2) added to a dielectric film containing TiO_2 as a primary component and the refractive index n of the dielectric film.

[Figure 13]

Figure 13 is a graph showing the relationship between the amount of nitrogen (N_2) added to a dielectric film containing TiO_2 as a primary component the extinction coefficient k of the dielectric film.

[Figure 14]

Figure 11 is a graph showing the relationship between the wavelength of a laser beam and the refractive index n of a dielectric film containing TiO_2 as a primary component.

[Figure 15]

Figure 12 is a graph showing the relationship between the wavelength of a laser beam and the extinction coefficient k of a dielectric film containing TiO_2 as a primary component.

[Figure 16]

Figure 16 is a graph showing the results of Evaluation # 1 of Optical Recording Medium Samples.

[Figure 17]

Figure 17 is a graph showing the results of Evaluation # 2 of Optical Recording Medium Samples.

[BRIEF DESCRIPTION OF REFERENCE NUMERALS]

10 ..... an optical recording medium

11 ..... a support substrate

11a, 12a ..... a groove

11b, 12b ..... a land

12 ..... a transparent intermediate layer

13 ..... a light transmission layer

13a ..... a light incidence plane

20 ..... an L0 layer

21 ..... a reflective film

22 ..... a fourth dielectric film

23 ..... an L0 recording film

24 ..... a third dielectric film

30 ..... an L1 layer

31 ..... a second dielectric film

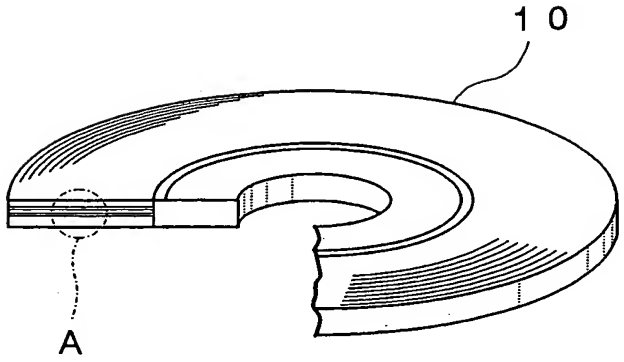
32 ..... an L1 recording film

33 ..... a first dielectric film

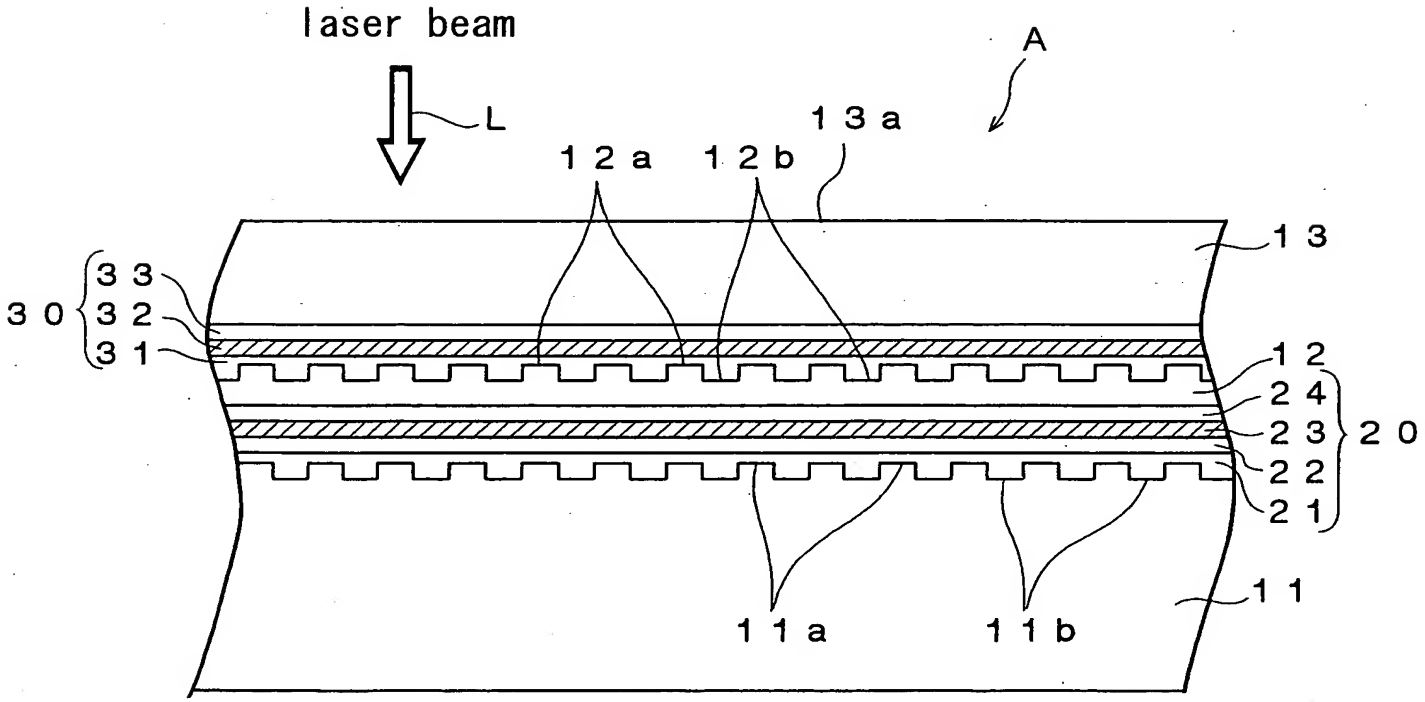
51, 52 ..... an inorganic reaction film

L ..... a laser beam

FIG. 1

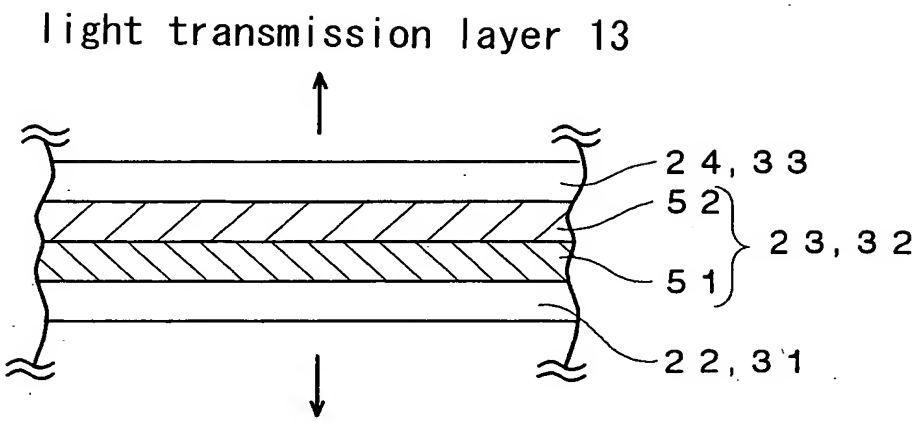


(a)

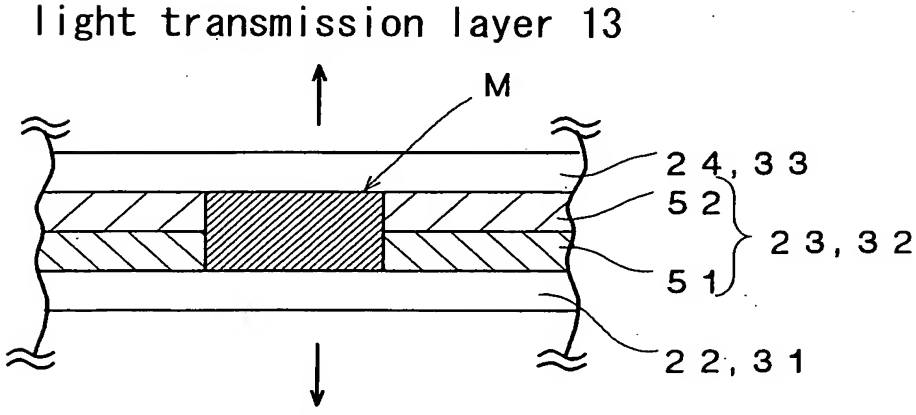


(b)

FIG. 2


light transmission layer 13
24, 33
52
23, 32
51
22, 31
support substrate 11

(a)


light transmission layer 13
M
24, 33
52
23, 32
51
22, 31
support substrate 11

(b)

FIG. 3

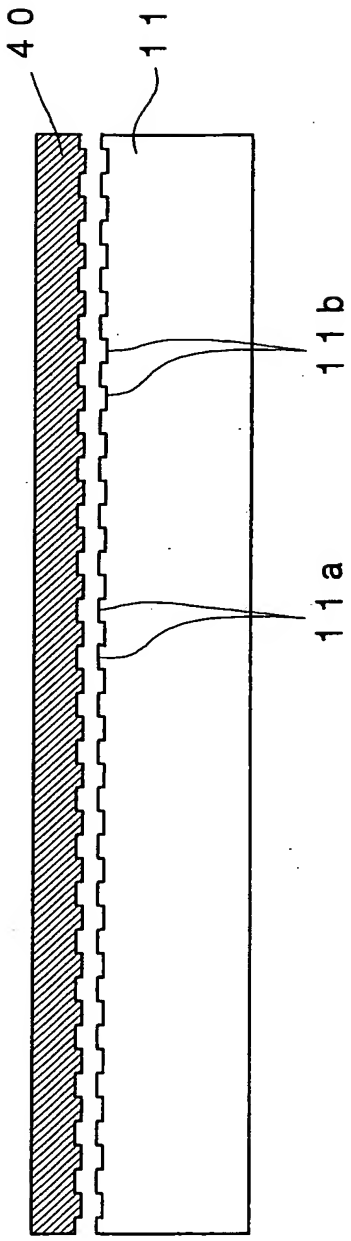


FIG. 4

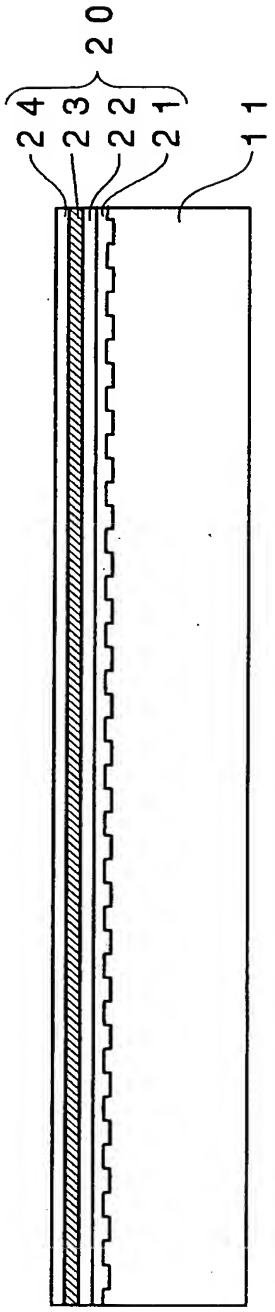


FIG. 5

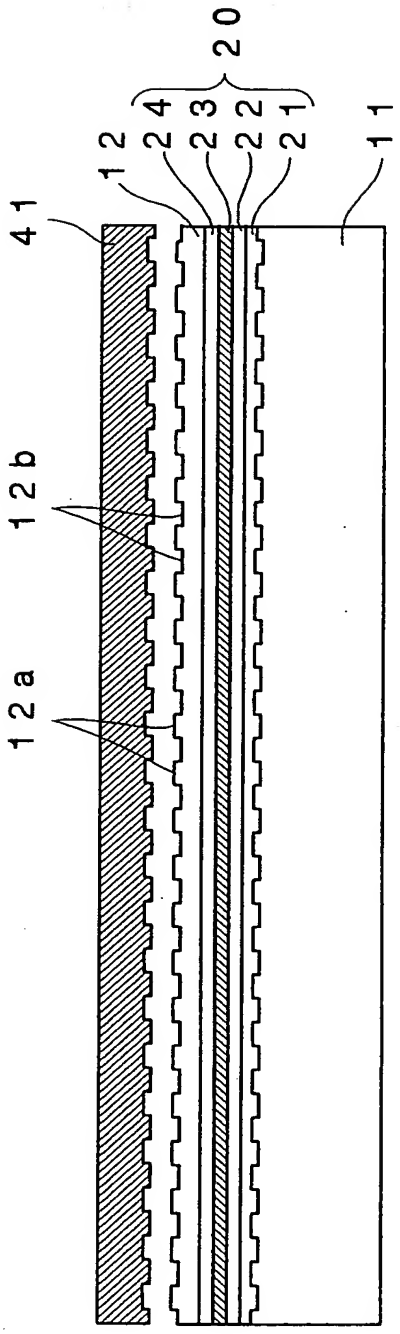


FIG. 6

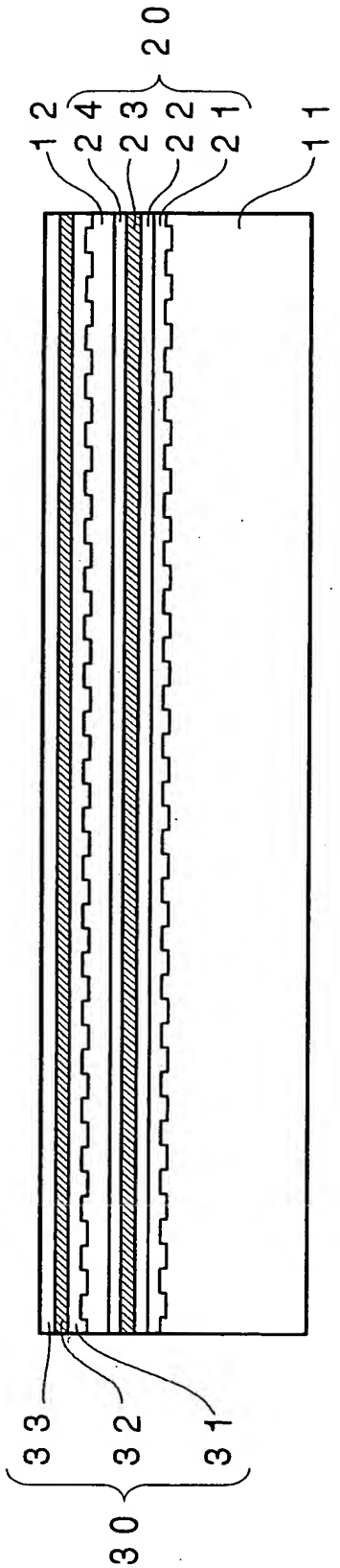


FIG. 7

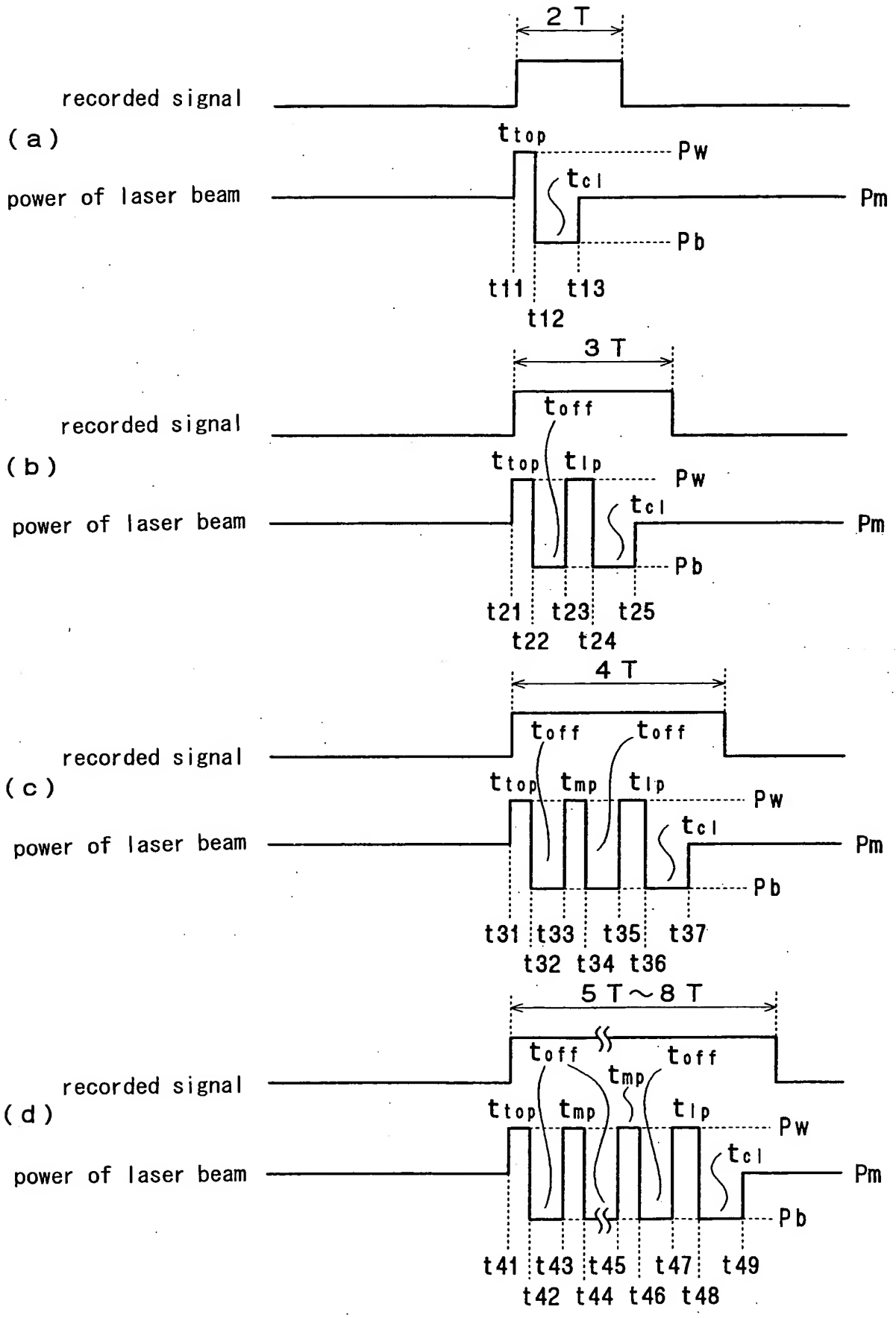

2 T
recorded signal
(a)
power of laser beam
ttop
Pw
tcl
Pm
Pb
t11
t12
t13
3 T
recorded signal
toff
(b)
ttop
tlp
Pw
power of laser beam
tcl
Pm
Pb
t21
t22
t23
t24
t25
4 T
recorded signal
toff
toff
(c)
ttop
tmp
tlp
Pw
power of laser beam
tcl
Pm
Pb
t31
t32
t33
t34
t35
t36
t37
5 T～8 T
recorded signal
toff
toff
tmp
(d)
ttop
tmp
tlp
Pw
power of laser beam
tcl
Pm
Pb
t41
t42
t43
t44
t45
t46
t47
t48
t49

FIG. 8

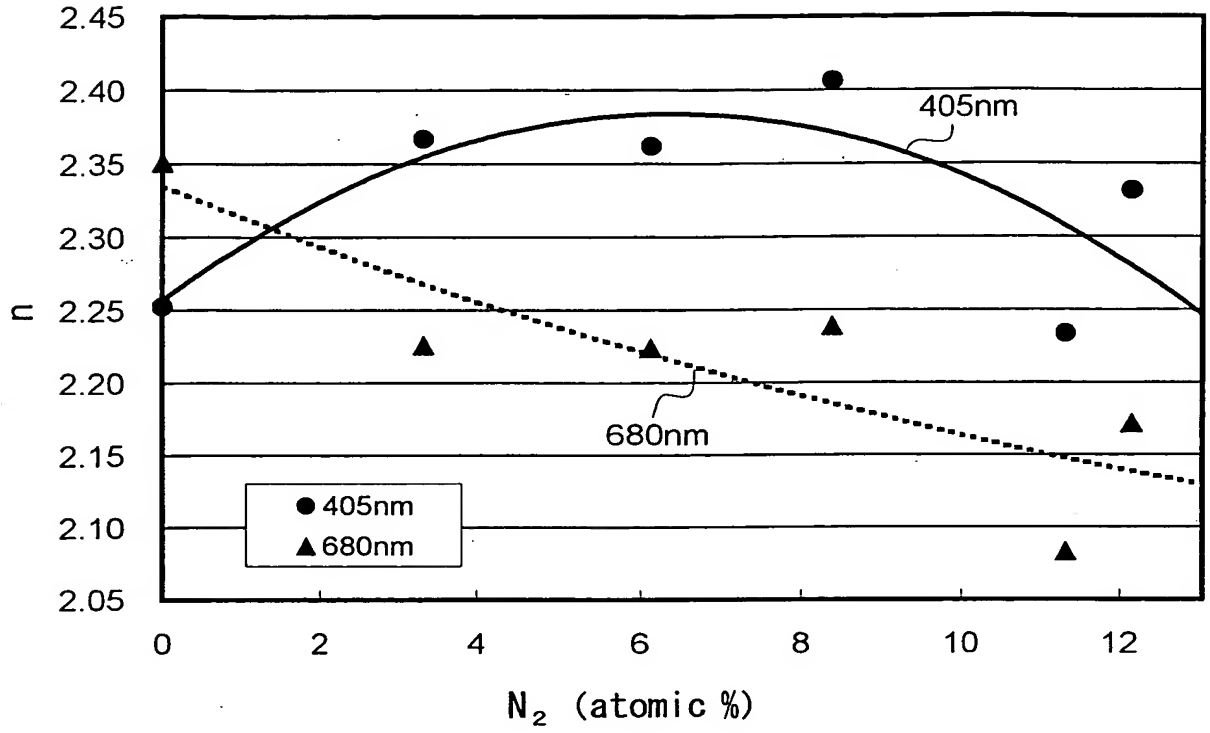

2.45
2.40
2.35
2.30
2.25
2.20
2.15
2.10
2.05
n
405nm
680nm
405nm
680nm
0
2
4
6
8
10
12
N2 (atomic %)

FIG. 9

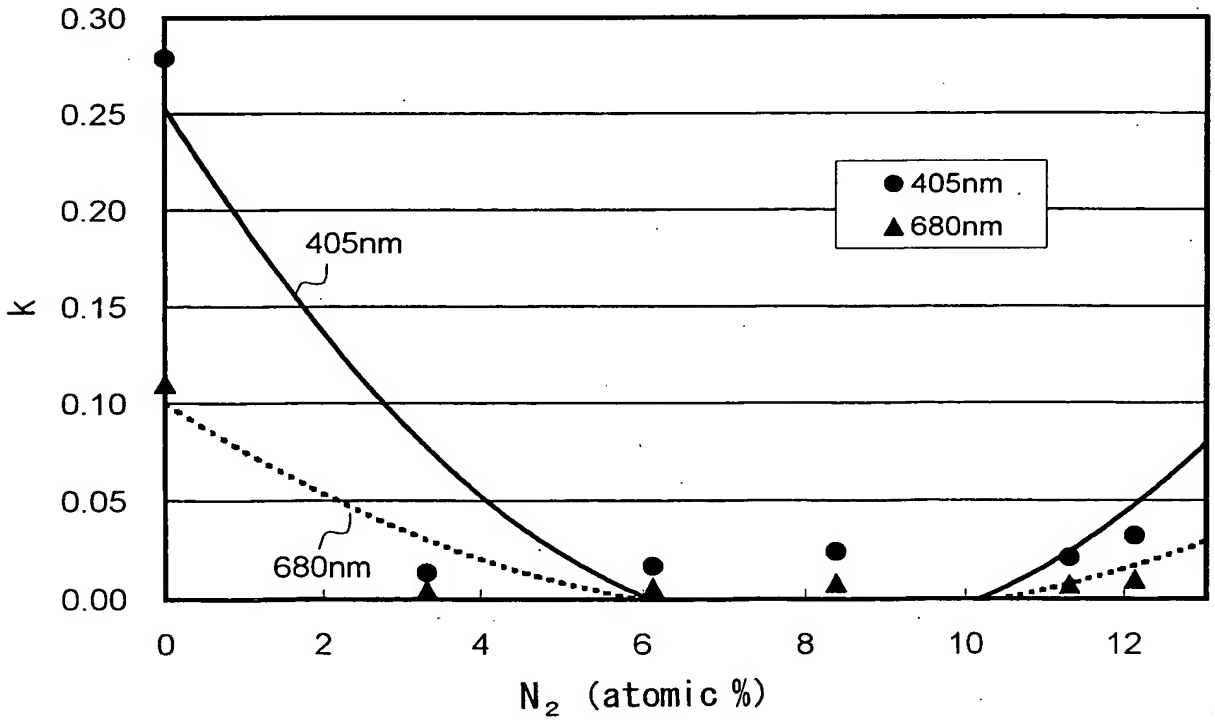

0.30
0.25
0.20
0.15
0.10
0.05
0.00
k
405nm
680nm
405nm
680nm
0
2
4
6
8
10
12
N2 (atomic %)

FIG. 10

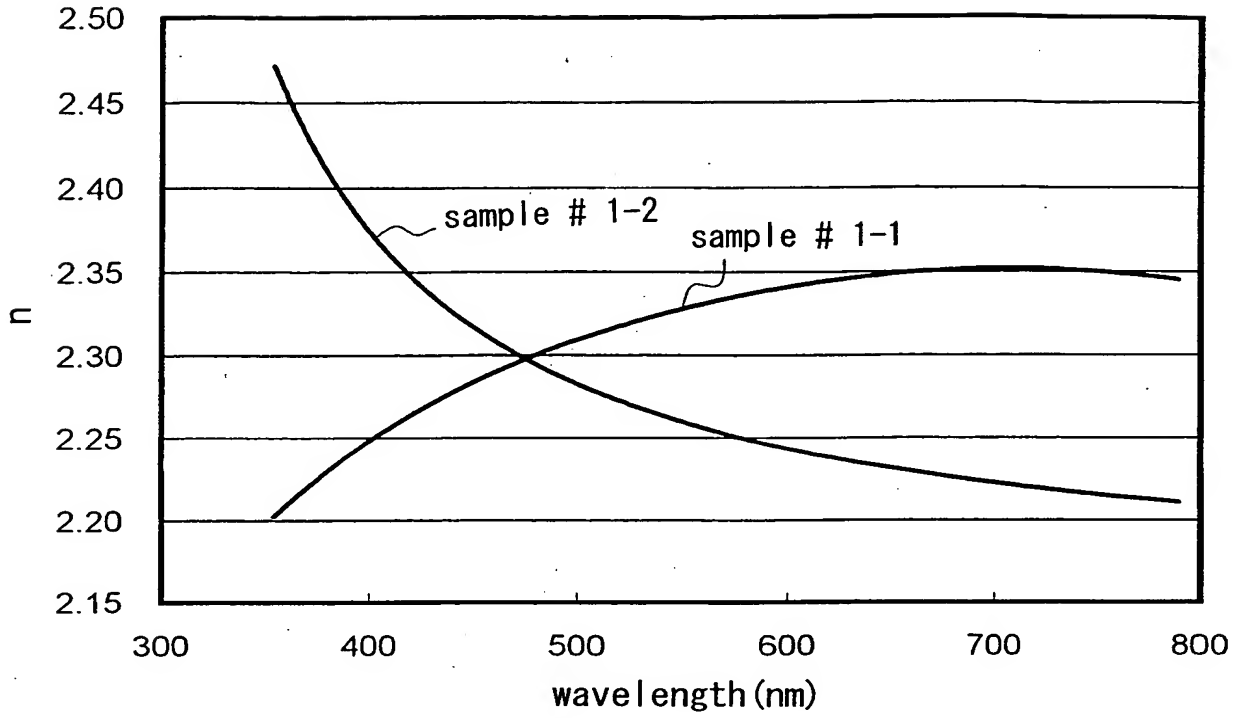

2.50
2.45
2.40
2.35
2.30
2.25
2.20
2.15
n
sample # 1-2
sample # 1-1
300
400
500
600
700
800
wavelength(nm)

FIG. 11

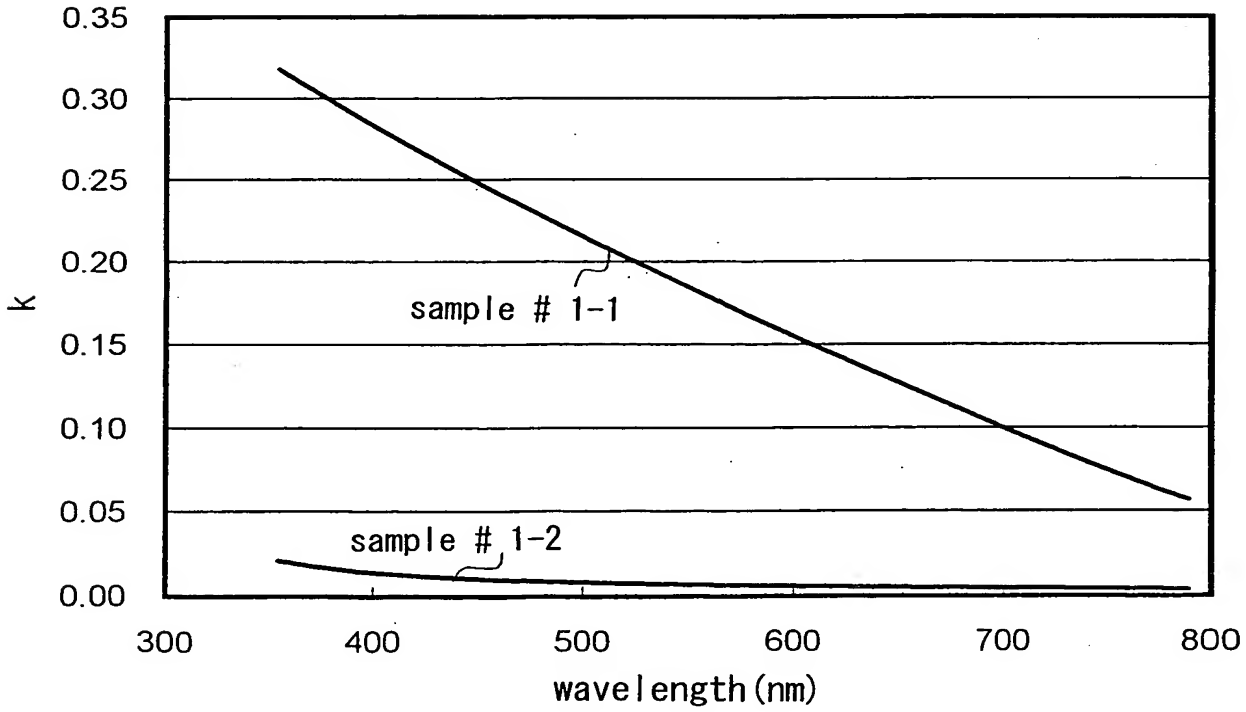

0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
k
sample # 1-1
sample # 1-2
300
400
500
600
700
800
wavelength(nm)

FIG. 12

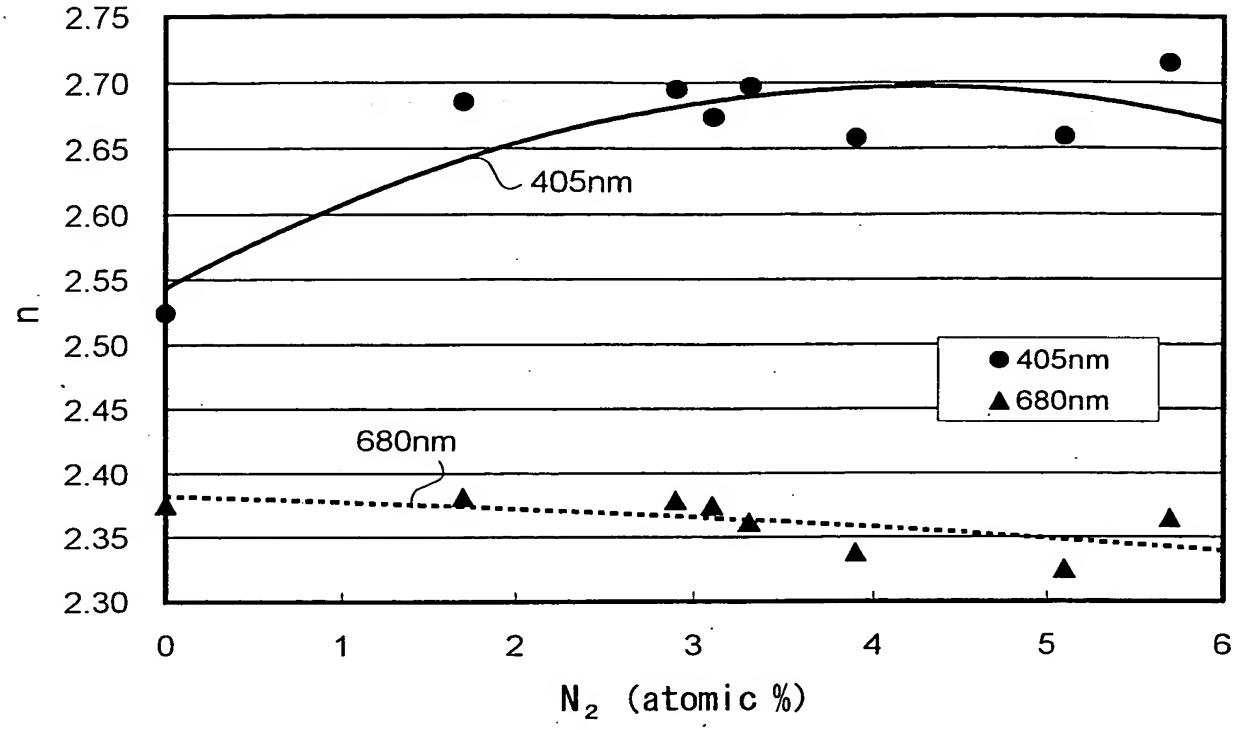

2.75
2.70
2.65
2.60
2.55
2.50
2.45
2.40
2.35
2.30
n
405nm
680nm
405nm
680nm
0
1
2
3
4
5
6
N2 (atomic %)

FIG. 13

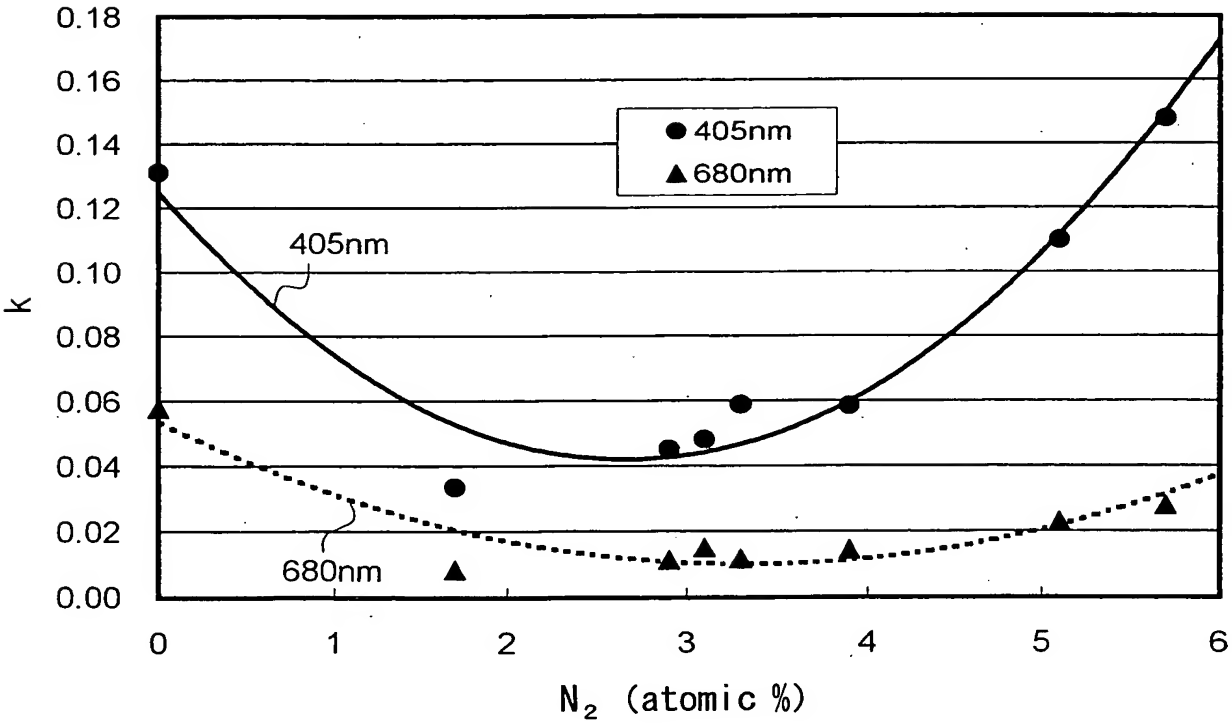

0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
k
405nm
680nm
405nm
680nm
0
1
2
3
4
5
6
N2 (atomic %)

FIG. 14

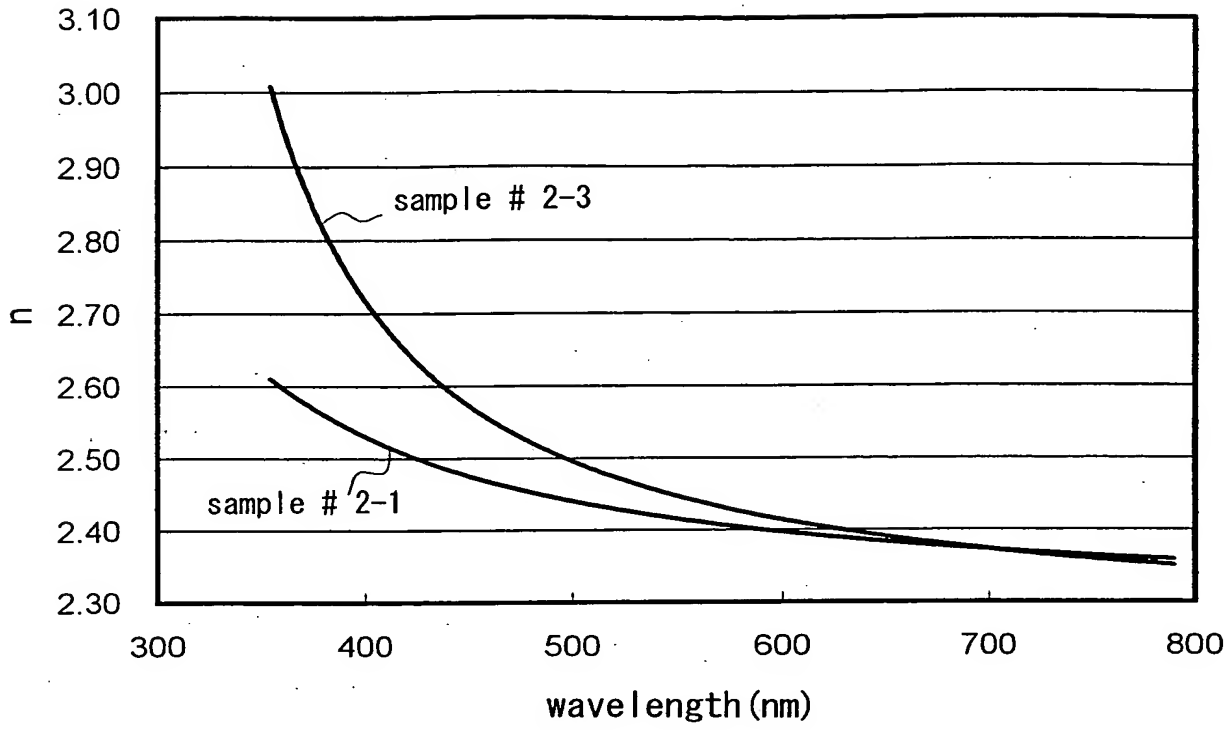

3.10
3.00
2.90
2.80
2.70
2.60
2.50
2.40
2.30
n
sample # 2-3
sample # 2-1
300
400
500
600
700
800
wavelength (nm)

FIG. 15

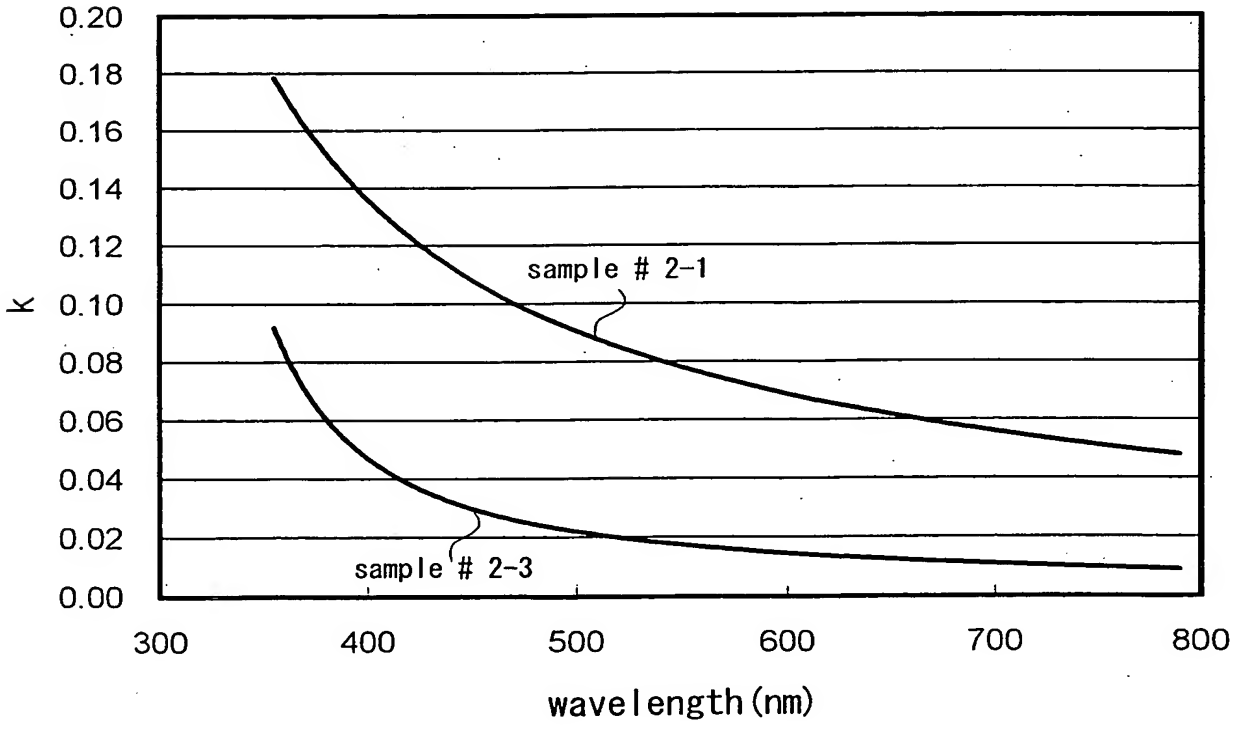

0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
k
sample # 2-1
sample # 2-3
300
400
500
600
700
800
wavelength (nm)

FIG. 16

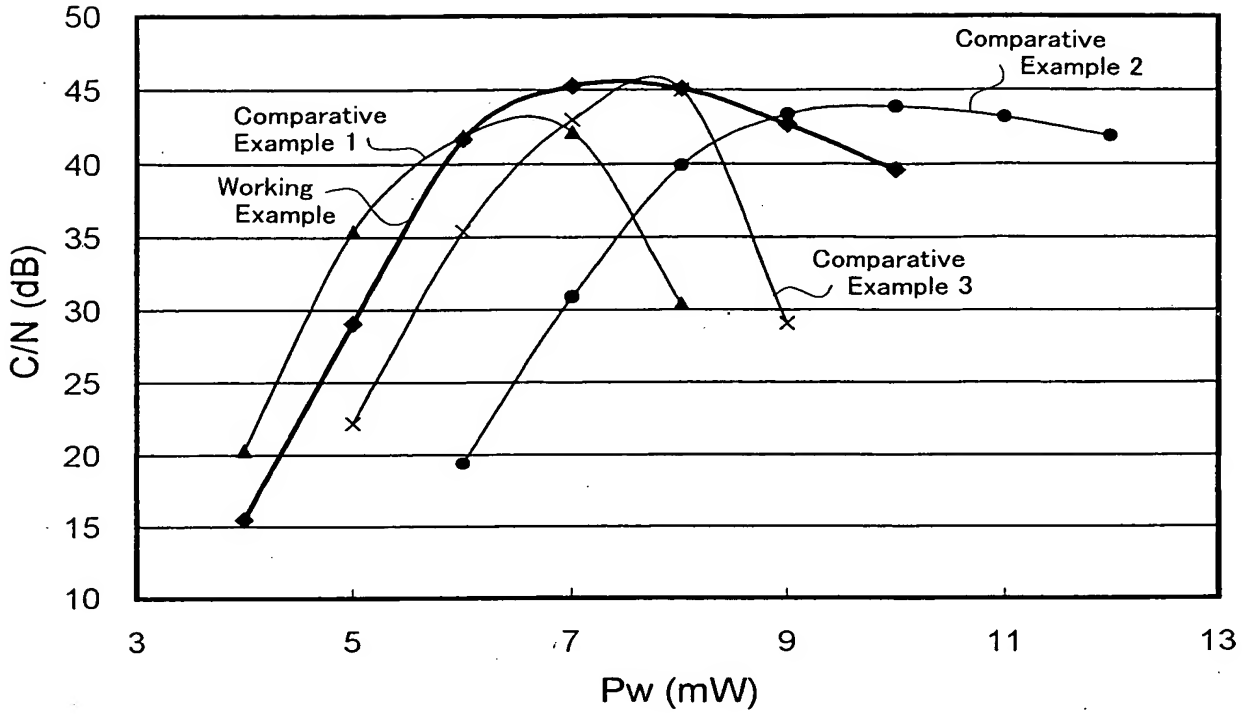
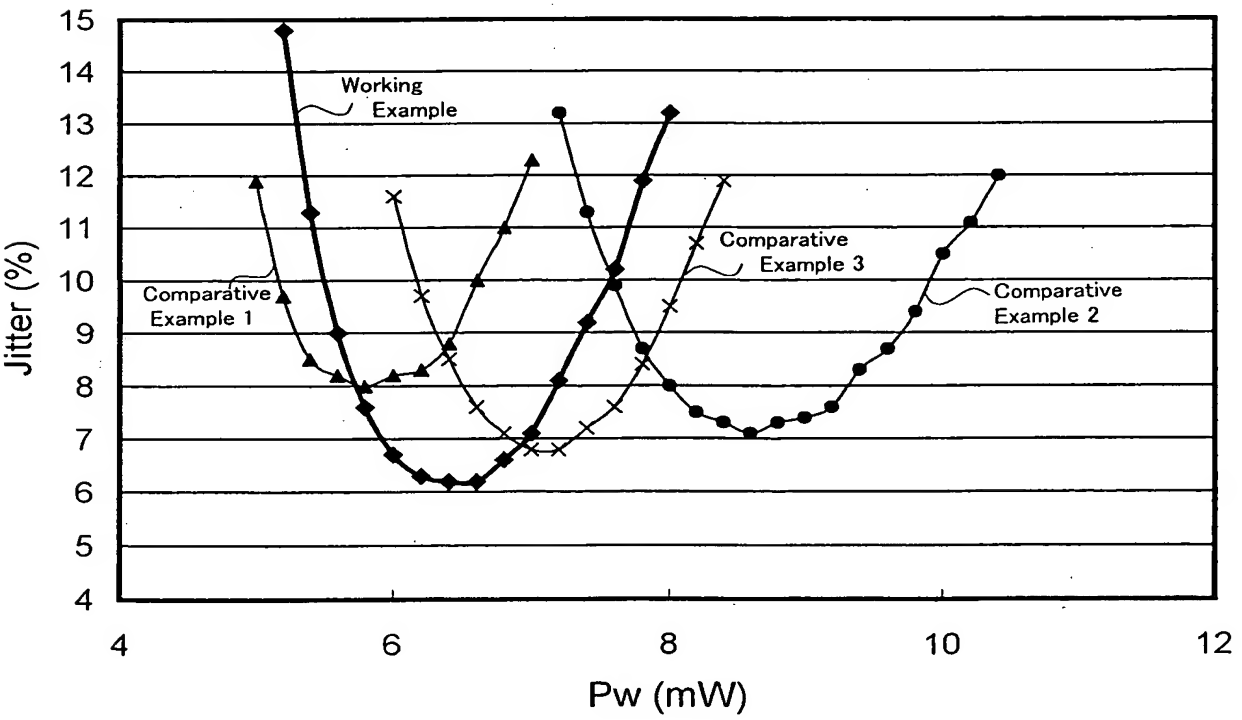

50
45
40
35
30
25
20
15
10
C/N (dB)
3
5
7
9
11
13
Pw (mW)
Comparative Example 2
Comparative Example 1
Working Example
Comparative Example 3

FIG. 17


15
14
13
12
11
10
9
8
7
6
5
4
Jitter (%)
4
6
8
10
12
Pw (mW)
Working Example
Comparative Example 1
Comparative Example 3
Comparative Example 2

[Name of Document] ABSTRACT OF THE DISCLOSURE

[Abstract]

[Problems]

It is an object of the present invention is to provide an optical recording medium which includes a plurality of laminated information recording layers and whose heat radiation characteristics and optical characteristics are improved.

[Solutions]

An optical recording medium according to the present invention includes a support substrate 11, a light transmission layer 13 and an L0 layer 20 and an L1 layer 30 provided between the support substrate 11 and the light transmission layer 13. The L1 layer 30 includes a recording film 32 formed of a plurality of inorganic reaction layers 51, 52, a first dielectric film 33 disposed on the side of the light incidence plane 13a with respect to the recording film 32 and a second dielectric film 31 disposed on the side of the support substrate 11 with respect to the recording film 32. The first dielectric film 33 contains a material prepared by adding nitrogen (N_2) to an oxide and the second dielectric film 31 contains a mixture of ZnS and SiO_2. In the thus constituted optical recording medium, it is possible to improve the heat radiation characteristics of the L1 layer 30 and at the same time, the L1 layer 30 can exhibit a high refractive index n and a low extinction coefficient k with respect to a laser beam of desired wavelength. Further, it is possible to improve the recording sensitivity of the optical recording medium and the productivity of the optical recording medium.

[Selected Figure] Figure 1